THE OCCURRENCE OF SUPERNUMERARY LIMBS IN AMBLYSTOMA FOLLOWING OPERATIONS FOR REMOVAL OR IMPLANTATION OF GONADIC PREPRIMORDIA[1]

R. R. HUMPHREY

Department of Anatomy, School of Medicine, University of Buffalo

During the study of Amblystoma larvae from which gonadic preprimordia had been extirpated, the writer ('27) encountered a number of animals in which supernumerary hind limbs had developed on the operated side. In later experiments ('28, '29, etc.), in which transplantation of the gonadic preprimordium was undertaken, supernumerary limbs were likewise encountered with considerable frequency in animals serving as donors. In hosts in which gonadic preprimordia had been implanted orthotopically, supernumerary hind limbs were also encountered, but far less frequently than in the donors of the same species. The circumstances under which these supernumerary limbs have made their appearance, together with a brief description of their form and relationships, seem worthy of record because of their possible value for comparison with the results secured by other investigators who have attacked the problem of limb reduplication or limb induction by various experimental methods (Harrison, '18, '21; Balinsky, '25, '26, '27, etc.; Swett, '26, '32; Filatov, '27; Detwiler, '30; Glick, '31, et al.).

The term 'gonadic preprimordium' as used by the writer designates the primordial germ cells and associated intermediate mesoderm extending from the level of the eighth or

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ninth somite to that of the sixteenth or seventeenth. In removal of this gonadic preprimardium for transplantation (or in preparing a host for reception of a transplant), the practice of the writer has been to include the adjacent portions of the related mesodermal somites, as well as a considerable extent of the related lateral mesoderm; these were all removed attached to the overlying ectoderm. Since in the younger embryos used in these experiments (stages 24 to 25 of Harrison's series) only 6 to 9 somites are distinguishable, in these and even in somewhat older embryos it has been the practice to extend the area removed back as close as possible to the blastoporic or anal opening. In the oldest embryos used (stages 30 to 33), in which a larger number of somites are distinguishable, the caudal extent of the area removed could be more accurately limited. That this area often extended well into the territory of the hind-limb rudiment is indicated by the complete absence of that limb in twenty-eight donors, or almost 3 per cent of the 1002 animals for which autopsy records are available.

Since the animals in which limb reduplication most frequently occurred were being reared for quite another study, the duplicate limb often escaped observation until it had attained a large size, or even until autopsy, and changes in these limbs during their development, consequently, were not followed. The occurrence of a supernumerary limb, however, was always recorded at autopsy, with notes on its form and point of attachment. Although these records, unfortunately, are in some cases less detailed than might be desired, they nevertheless give a fair good picture of the reduplications encountered.

INCIDENCE OF REDUPLICATION

A complete summary showing the frequency of hind-limb reduplication in the writer's material is presented in table 1. It will be readily noted that the limb is duplicated almost eight times as frequently in donors as in hosts. The occurrence of reduplication in A. punctatum is also seen to

be about twice as frequent as in A. tigrinum, while in A. jeffersonianum reduplication under the same conditions is rare (less than 1 per cent). Marked differences between A. punctatum, A. tigrinum, and A. microstomum, with respect

TABLE 1

Reduplication of the hind limb following removal of the gonadic preprimordium or its implantation in the orthotopic position

TYPE OF OPERATION AND SPECIES USED	NUMBER OF CASES	NUMBER OF REDUPLICATIONS	PER CENT REDUPLICATED
I. Removal of gonadic preprimordium ('donors')			
A. A. punctatum	508	112	22.0
B. A. tigrinum	384	42	10.9
C. A. jeffersonianum	110	1	0.9
Totals, all donors	1002	155	15.5
II. Orthotopic implantation of gonadic preprimordium ('hosts')			
A. A. punctatum	488	13	2.7
B. A. tigrinum	503	8	1.6
C. A. jeffersonianum	112	1	0.9
Total, all hosts	1103	22	2.0
Totals, donors and hosts combined	2105	177	8.4

TABLE 2

Reduplication of the hind limb in A. punctatum donors secured from various localities

LOCALITY AND YEAR	NUMBER OF CASES	NUMBER OF REDUPLICATIONS	PER CENT REDUPLICATED
Buffalo, New York, 1926 to 1932	368	68	18.5
Imboden, Arkansas, 1929	78	26	33.3
Nashville, Tennessee, 1930	21	8	38.1
New Haven, Connecticut, 1930	41	10	24.4
Totals	508	112	22.0

to frequency of reduplication under other experimental conditions, have been encountered by Swett ('32) and other investigators.

The A. punctatum donors included in table 1 were procured from four different localities. The percentage of limb reduplication in each of these strains is indicated in table 2.

Although the animals from Arkansas and Tennessee show a much greater proportion of reduplications than do those of the Buffalo or New Haven strains, it is quite probable that these differences result from variations in operative technique, age of embryos at operation, or other uncontrolled factors, and do not indicate actual differences in the inherited potentiality for limb reduplication, such as have been found to occur between various species of Amblystoma. In certain groups of animals of the Buffalo strain, in fact, the percentages developing supernumerary limbs approach those found in Arkansas or Tennessee strains.

TABLE 3

Reduplication of the hind limb of Amblystoma following heteroplastic and homoplastic transplantation of the gonadic preprimordium

COMBINATION USED		NUMBER OF CASES	NUMBER OF REDUPLICATIONS	PER CENT REDUPLICATED
Host species	Donor species			
Punctatum	Punctatum	294	8	2.7
Punctatum	Tigrinum	168	5	2.9
Punctatum	Jeffersonianum	26	0	0.0
Tigrinum	Tigrinum	351	5	1.4
Tigrinum	Punctatum	152	3	2.0
Jeffersonianum	Punctatum	74	1	1.4
Jeffersonianum	Tigrinum	38	0	0.0

Among the hosts included in table 1 are a large number in which the grafts were furnished by donors of another species. The occurrence of supernumerary limbs following such heteroplastic transplantation is not significantly greater than that after homoplastic transplantation, as is shown in table 3. The punctatum host apparently exceeds the tigrinum in its tendency toward limb reduplication, regardless of the species of the donor—a finding to be expected on the assumption that the reduplicant is commonly derived from tissues of the host rather than from those of the graft (p. 9).

FORM AND POSITION OF SUPERNUMERARY LIMB

The form of the supernumerary limb was recorded in 152 cases. The type most frequently encountered (37 per cent of

all cases) is a disharmonic limb of five digits, located anterior to the normal hind limb, of which it is commonly the mirror image. In 9 per cent of all cases recorded, the reduplicant possesses but 4 digits; in 20 per cent either 2 or 3 digits are present; and in 14 per cent the limb is rudimentary or abortive, consisting merely of a limb-like stub, or possessing but one typical digit. Whether such defective limbs are the result of incomplete differentiation or are due to a secondary reabsorption cannot be stated, since the course of development of the reduplicants was not followed. In 11 per cent of all recorded cases a further reduplication has occurred, giving rise either to additional digits on the first reduplicant or to a more or less complete third limb. Such limbs, when best developed, are clearly mirror images of the first reduplicant, and therefore have essentially the same orientation as the normal hind limb.

Types of reduplication other than those noted above are occasionally developed. Thus in four cases the normal or harmonic hind limb of the operated side is located anterior to the disharmonic member, rather than in the usual position behind it; in two cases the harmonic member has undergone a partial reduplication, while the disharmonic limb ahead of it is without such reduplication; and in two cases both the normally placed limb and the more anterior disharmonic member have undergone partial reduplication. In one case two complete supernumerary limbs are present, both harmonic in orientation, giving three limbs on the right, each of perfect form, except for the branching of certain digits—a feature present also in the left hind leg of the same animal.

The point of attachment of the supernumerary limb was usually recorded. Approximately three-fourths of all reduplicants are essentially complete limbs; the remainder attach to the thigh of the harmonic member, or more distally, twenty-one (12 per cent) being reduplications of the foot alone or of its digits. In seventy-three cases the reduplicant was recorded as attaching 1 mm. or more from the harmonic limb, but in very few cases is its attachment more than 5 mm. dis-

tant. Those supernumerary members most distal from the normal hind-limb site are frequently associated with fistulous openings from the digestive tract resulting from faulty or incomplete healing after removal of the gonadic preprimordium; such associations of limb and fistula occur in one-fourth of all the donors showing limb reduplication.

The occurrence of additional girdle elements in association with limb reduplicants was not studied. Since these limbs sometimes exhibit movements correlated with those of the normal limb, their attachment to girdle elements is indicated.

DISCUSSION

Reduplication of limbs has been secured by other investigators under a great variety of experimental conditions. Since it was brought to prominence by the experiments of Harrison ('18, '21), the problem of limb reduplication following the transplantation of embryonic limb rudiments has been attacked by several investigators (compare Swett, '26, '32; Detwiler, '30). Swett ('26) has stimulated a reduplication of limbs by dividing the limb rudiment or the early embryonic limb bud and keeping the halves separated by a transplant of indifferent material. Balinsky ('25, '26, '27, '29) and Filatov ('27) have described the occurrence of 'induced' limbs associated with transplants of the embryonic otic vesicle, and Balinsky has recorded the development of such a limb in one instance following the implantation of a piece of celloidin. Glick ('31) has recently described the development of supernumerary limbs in association with transplants of the nasal placode.

While the experiments of Swett, Harrison, and others show clearly that disturbances applied to a limb bud before its differentiation may bring about reduplication, the results of Balinsky, Glick, and others (compare Glick, '31) have been interpreted as indicating that the development of a limb can be induced at any point in the lateral body wall by the implantation of various organ rudiments (otic vesicle, nasal placode, spinal cord, gills, heart) or even by the introduction

of a mass of inert material. The frequent occurrence of limb reduplication following operative injury (as reported in this paper) without the implantation of any material which might serve as an inductor, would, however, seem to require a careful reexamination of any case regarded as a limb induction, to determine whether the limb in question might not equally well be interpreted as the result of a disturbance applied to the limb-forming area.

It is obvious that the cases of limb reduplication encountered by the writer in animals used as donors must be ascribed to the disturbance of the limb rudiment at operation or during the healing process, rather than to the introduction of any specific limb inductor. In the removal of a gonadic preprimordium for grafting, a fairly large area of entoderm is left exposed. The healing over of such a wound is accomplished by the crowding together of the cut edges of the ectoderm and mesoderm which surround the wound, and by the migration of cells from these cut edges to cover the denuded entoderm. When the area removed at operation extends caudally into the neighborhood of the hind-limb rudiment, it is readily seen that the latter may suffer considerable disturbance (or even partial or total removal; p. 2), or that a portion of its material may undergo more or less displacement cephalad in the healing process which follows. Such a migration of limb-forming material, it is believed, is the most logical explanation of those supernumerary limbs found farthest cephalad. These, it has already been pointed out, are frequently associated with intestinal fistulae resulting from faulty or incomplete healing of the wound left after operation. In these cases, it may be assumed, a part of the limb-forming material has been carried far cephalad in the attempt at healing; this material has then given rise to a supernumerary limb located caudal to the fistula resulting from the rupture of the gut at the point where its entoderm remained uncovered. The rather constant occurrence of the supernumerary limb in a location caudal to the fistula is readily understandable on this interpretation. If, however, one should assume that

the limb arises as the result of a process of induction, from material of the lateral mesoderm which normally does not participate in limb formation, then its restriction to positions caudal to the supposed inductor (i.e., the open wound or fistula) would be difficult of explanation; limb formation should occur at any border of the wound or fistula as readily as at its caudal margin.

It is entirely possible that many or even all of the supposed limb inductions reported by Balinsky and others may be the result of migration of limb-forming material into the region of the implant. Balinsky ('29), after staining the fore-limb rudiment with Nile-blue sulphate, noted in some instances a displacement of the stained mesoderm into the region of the implant. Although he found the stained material to give rise to cartilages at the base of the 'induced' limb rather than to the limb itself, it is by no means impossible for unstained limb-forming material from the more peripheral part of the limb-forming area to have migrated into the region of the implant in addition to that which had been stained. The actual limits of the area capable of limb formation are difficult to determine, Harrison ('18), for example, reporting the regeneration of a fore limb in over 80 per cent of all cases following removal of areas 3 to 4 somites in width. Glick ('31), after a supposedly complete excision of the fore-limb rudiment, similarly found a regeneration of the limb in five out of eleven cases. In view of these results, it would seem entirely possible for limb-forming material to be displaced into the neighborhood of an implant inserted only a short distance from the limb rudiment, even though the latter were removed and no limb were regenerated at the normal site. The one photograph of an 'induced' limb shown in Glick's paper indicates that this member is no farther distant from the normal limb than are the supernumerary limbs of many donors of my series in which no inductor has been implanted. It would be of considerable interest in this connection to know the location of all supposedly induced limbs with reference to the tissue serving as an inductor. If such limbs are

always situated between the supposed inductor and the adjacent normal limb, their development from displaced material of the normal limb rudiment would be suggested. If, on the other hand, these supernumerary limbs arise at any point around the circumference of the supposed inductor, their development from entirely indifferent material under its influence might be more confidently asserted.

As to the limb reduplicants of my series which are located closer to the normal hind leg, their origin from limb-rudiment material which has undergone less marked shifting during wound healing may be postulated. In those animals in which the reduplicant is joined to some part of the normal or harmonic limb, it may in some instances have fused secondarily to the latter; in other cases, doubtless, a splitting or reduplication has occurred in an originally single limb as a result of the disturbance consequent to the operation or the healing process.

In those cases in which reduplication of the hind limb has occurred after grafting (hosts), it seems probable that the same factors are operative as in the donors. Reference to table 1 indicates that reduplication in hosts occurs with comparative rarity, only twenty-two cases having been encountered in 1103 animals carrying orthotopic transplants. This is understandable on the assumption that the implanted gonadic primordium effectually reduces or prevents that displacement of the material of the hind-limb rudiment which is assumed to favor the development of supernumerary limbs. On the basis of this assumption, the hosts possessing hind-limb reduplicants might be expected to exhibit a high percentage of defects in the development of the graft derivatives, due to imperfect union of graft and host tissues or to partial loss of the graft through necrosis. Examination of the autopsy records of these hosts shows this condition actually to obtain. Of the twenty hosts with supernumerary limbs so far autopsied, the graft derivatives are recorded as normal in but five. Defects in the other fifteen range from a slight reduction or irregularity in the mesonephros to a complete

or practically complete absence of the usual graft derivatives (mesonephros, wolffian duct, gonad, fat body). In one host a lateral fistula serving as an anus was located immediately anterior to the two abortive supernumerary limbs, in two others the wolffian duct opened through the lateral body wall, and in several others the mesonephros was irregular or interrupted caudal to the territory of the gonad, indicating an imperfect union of the caudal end of the graft with the germ layers of the host. In these hosts, therefore, conditions favorable to the displacement of limb-rudiment material doubtless prevailed during the healing process much as in the donor embryos.

It appears probable, therefore, that hind-leg reduplication in hosts following orthotopic implantation of gonadic preprimordia usually depends upon the same factors (disturbance or displacement of limb-forming material) as in the donors. The graft does not stimulate or induce limb formation in areas in which limb-rudiment material may not be present. This assertion is supported by the results obtained when gonadic preprimordia are transplanted heterotopically into ventro-lateral sites (Humphrey, '28). No supernumerary limbs have been found associated with grafts of this type, although almost 200 hosts carrying such grafts have been autopsied. The heterotopic graft is, of course, implanted at a greater distance from the hind-limb rudiment than the orthotopic graft, and hence has little or no tendency to cause disturbance or displacement of the limb-forming material.

The question of limb asymmetry has been discussed at considerable length by Harrison ('21) and Swett ('26), to whose papers the reader is referred. As previously stated, the reduplicants encountered in my animals tend to be mirror images of the normal or harmonic hind limb lying caudal to them, much as the reduplicant developed after transplantation of a limb rudiment mirrors the primary limb. My material also illustrates the tendency of a reduplicant to form a tertiary limb on the side toward the normal limb, the tertiary member thus formed being a mirror image of the original

reduplicant and thus of the same asymmetry as the harmonic limb. Several departures from these more typical relationships have been noted (p. 5). Many cases are, of course, impossible to classify because of the rudimentary or abortive character of the reduplicant.

Since the factors determining the asymmetry of the developing limb and the reversal of asymmetry in limb reduplicants remain more or less obscure, despite the numerous attempts to determine their nature, no adequate explanation can be offered for the asymmetry of the reduplicants reported in this paper. The possibility that all reversals of asymmetry are due to alterations of a physiological gradient in the limb-forming material is an entertaining speculation at present lacking experimental evidence in its support.

SUMMARY AND CONCLUSIONS

1. Reduplication of the hind limb has been found to occur with considerable frequency following extirpation or orthotopic implantation of the gonadic preprimordium. In these operations the area extirpated or transplanted included the intermediate segment and adjacent parts of the axial and lateral mesoderm from the eighth or ninth to the sixteenth or seventeenth somite.

2. Limb reduplicants were encountered with greatest frequency (15.5 per cent) following extirpation of the area noted above. Reduplication after orthotopic implantation of this area accurred in a much smaller proportion of cases (2 per cent). Amblystoma punctatum (maculatum) exhibited the most pronounced tendency toward development of supernumerary members (12.5 per cent of all operations); reduplication occurred less frequently in A. tigrinum (5.6 per cent), and only rarely in A. jeffersonianum (0.9 per cent).

3. The reduplicant in a high percentage of cases is a disharmonic member—a mirrow image of the normal hind limb. It may unite with the latter or attach separately at some more anterior point.

4. The reduplication described is interpreted as resulting from disturbance or displacement of the limb-forming material at operation or during the subsequent healing process, the area extirpated or implanted probably extending well into the territory of the hind-limb rudiment. The smaller percentage of reduplications occurring after orthotopic implantation is probably due to the diminished opportunity (or necessity) for displacement or migration of the limb-forming material during healing.

Postscript. After the foregoing paper had been accepted for publication, the development of a number of reduplicants was closely followed in a group of 76 donors of a Tennessee strain of A. punctatum, among which 25 (33 per cent) exhibited supernumerary limbs. This study permits a positive statement regarding certain points on which data were previously lacking, as follows: 1) The limb bud for the harmonic member appears first in development. When the reduplicant is a separate limb, it develops from a bud which usually appears shortly after that for the harmonic member. When the reduplicant is not a separate limb, it is commonly formed by the subdivision of the terminal portion of the bud for the harmonic member, the two divisions of which then develop more or less synchronously. 2) Reduplicants having the form of a stub either ending bluntly or tapering to a slender, more digit-like structure, result from lack of continued differentiation in the limb bud rather than from secondary absorption of digits once formed. The absence of one or more digits in reduplicants of more typical limb-like structure is likewise due to faulty or incomplete differentiation rather than to a secondary resorption.

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EXPERIMENTAL STUDIES ON THE HYPOPHYSIS CEREBRI

II. THE EFFECT OF CASTRATION IN THE MALE ALBINO RAT

SAM I. STEIN
Department of Anatomy, University of Minnesota

TWO FIGURES

INTRODUCTION

One of the more important methods employed in investigating the relation of the hypophysis to the sexual cycle is castration. Although much controversy still exists regarding the facts elicited by this indirect method, it is believed that the finer distinctions in function constantly being attributed to the hypophysis might be substantiated if more refined quantitative methods were to be used. With this object in view, the present study has attempted to show, by means of careful volumetric, histologic, and statistical methods, the changes induced by castration in the whole weight of the hypophysis and in the weight and volume of its individual lobes.

REVIEW OF LITERATURE

A survey of the literature shows striking disagreement in the observations made by various authors not only upon different groups of animals, but upon the same species.

A. Changes in size of the hypophysis

a. Increase in size. Kon[1] ('08), and Berblinger ('24), for the human male and female; Fichera ('05), Cimorini ('08),

[1] References not cited in bibliography may be found in "Sex and internal secretions", Allen, E., 1932. Williams & Wilkins Co., Baltimore.

Kolde ('12), Schenk ('26), and Brauer ('28), for male and female rabbits; Zacherl ('12), Hatai ('15), Addison ('17), Kojima ('17), Izumi ('22), Mottran and Cramer ('23), Nukarija ('26), Schenk ('27), and Lehman ('28) for male and female rats (Schenk states that 20 months after castration the gland is back to normal); Fichera ('05), Wittek ('13), and Schonberg and Sakaguchi ('17) for oxen; Fichera ('05), Marassini and Luciani ('11), and Massaglia ('20) for capons; Cimorini ('08), Trautman ('09), and Obrossow ('18) for male and female dogs and pups; Trautman ('09), and Schenk ('27) for male and female cats; Trautman ('09) and Saito ('23) for the horse; Kostner ('31) for swine; and Rosta ('31) for cows.

b. Absence of enlargement. Marassini and Luciani ('11) and Livingston ('14) for male and female rabbits; Kolde ('12) and Rössle ('14), for the human female; Pirsche ('02) and Marassini and Luciani ('11), for male and female guinea pigs; Baker ('28) for pigs; and Marassini and Luciani ('11), for sheep, oxen, and dogs.

c. Decrease in size. Kühn ('10), in horses, and Moore ('22), for guinea pigs.

No reports specifying changes in size of the individual lobes could be found.

B. Histologic changes

a. Increase in number of eosinophilic cells. Kon ('08), Kolde ('12), and Rössle ('14) for the human female; Fichera ('05), Cimorini ('08), Kolde ('12), and Brauer ('28) for male and female rabbits; Fichera ('05), Massaglia ('20), and Marassini and Luciani ('11) for capons and domestic fowl; Fichera ('05), Kolde ('12), and Trautman ('09) for guinea pigs and swine; Kühn ('10), Trautman ('09) for horse and donkey; Izumi ('22) and Lehman ('28) for male and female rats; Cimorini ('08), Parhon and Golstein ('08), Trautman ('09), and Obrossow ('18) for dogs and pups; Parhon and Golstein ('08), and Trautman ('09) for cats.

b. Increase in number of basophilic cells. (Those which become enlarged and vacuolated are frequently spoken of as castration cells): Zacherl (Biedl) ('12), Schleidt ('14), Addison ('17), Hayomi ('19), Nukarija ('26), Satwornitzkaja ('27), Schenk ('27), and Lehman ('28) for male and female rats; Marassini and Luciani ('11) for capons; Biedl ('12) and Obrossow ('18) for dogs and pups.

c. Increase in number of neutrophilic cells. Kon ('08) for the human male; Okintschitz ('14) for the rabbit; Mottran and Cramer ('23) for the male rats.

d. Absence of histologic changes. Kühn ('10) for the horse; Wittek ('13) for the ox; and Marassini and Luciani ('11) for the ox, rabbit, guinea pig, dog, and sheep.

MATERIAL AND METHODS

The animals used in this investigation consisted of forty-three male albino rats (Mus norvegicus albinus) of standard, vigorous Wistar stock carefully reared from birth to the time of autopsy.

The animals were divided into five groups (two groups of control and three groups of test animals), according to duration of castration period, fixing material used, or operative technique.

The test animals were castrated on the twenty-first to twenty-third day of life and were killed from 60 to 80 days after castration.

The groupings and designations of each group are as follows:

Control animals

1. Eight animals designated 'control I,' littermates of 'test castration' animals, and killed on the same day. These were autopsied by the author and preserved in the same solutions as the 'test castration' glands.

2. Eight animals designated 'control II,' littermates of the 'castration complete' and 'epididymis intact' groups, and killed on corresponding days. These were autopsied by Lawlses and also preserved in Zenker-formol solution.

Test animals

1. Nine animals designated 'test castration.' autopsied by the author, after having been castrated for a period of approximately 68 days. The epididymis in these animals was not removed. The hypophyses were preserved in a saturated solution of mercuric chloride to which was added 10 per cent formalin.

2. Eleven animals designated 'complete castration,' autopsied approximately 88 days after castration. In these animals the epididymis was removed with the testes. The glands were preserved in Zenker-formol solution.[2]

3. Seven animals designated 'epididymis intact,' autopsied by Lawless, castrated approximately 88 days. The epididymis was not removed in these animals. These were also fixed in Zenker-formol solution.

A control operation which included all the stages except removal of the testes was performed on both groups of controls so that all animals were subjected to approximately the same amount of trauma.

The animals were killed by being placed in a closed jar containing chloroform. Special care was given to the removal of the hypophysis during autopsy to avoid excess drying or mechanical injury.

The paraffin sections were cut at 3 and 5 μ. A volumetric study of the three lobes and a histologic survey of the anterior lobe were then made. The procedure used was that of Hammer ('14). Every tenth section was mounted and stained with haematoxylin and eosin. The image of each section, magnified 33 diameters, was outlined on paper of uniform thickness, cut out and weighed on a chemical balance. From the weights so obtained the percentage of each lobe was calculated.

For the histologic study about five sections were taken at graded intervals and stained with Mallory's triple connective tissue stain after a light preliminary staining with hematoxylin.

[2] For this material, the writer is greatly indebted to J. J. Lawless, of this department, who is studying the effects of castration on the various organs of the body.

The effects of castration on either the weight of the hypophysis, the weights of its lobes, body weight or body length have been measured by finding the difference between the respective means for each experimental group and its control group. The significance of the difference between the means was tested by the statistical principle that a difference between two means is possibly significant when it is two times its standard error, and probably significant when it is three times its standard error. The equations given by Dunn ('28) were used in calculating all constants. These interpretations of significance are based on the fact that chance alone would cause such a difference first only five times in 100, i.e., the probability integral, P, is 0.05, and second only once in 100, i.e., P is 0.01. Hence in all probability the observed difference is due to the experimental procedure and not just chance differences in the animals.

After the differences between each test and its control group were found to be of the same order, the various small test groups were combined into one experimental group and their controls into one control group. The various groups were of different ages and the animals were young enough so that there was still a normal increase in body weight and length of the control animals, as well as in the weight of the hypophysis. This normal increase can be described by the regression line and its equation $Y = (y - Bx) + Bx$, when y is used successively to designate whole weight of hypophysis or its individual lobes, body weight of the animal, or body length of the animal; x is age, y is the mean of the observed values for any of the factors that y stands for, x is the mean age and b is the regression coefficient of y on x. Since y, x, and b are statistical constants to be calculated from the observed data, using the Pearsonian correlation technic, the values in the parenthesis may be considered one constant a. The equation becomes $y = a + Bx$.

The slope of the regression line is represented by the regression coefficient, B, which indicates the average increase in y for each day.

The rates of increase, then, in body weight, body length, the weight of the whole hypophysis and its parts for the test and control animals may be compared by testing for the differences between their respective regression coefficients in the same manner as between the comparable means.

If the mean ages of the control and experimental groups are the same and the regression coefficients are of the same sign, the differences between the means of the weights of the whole hypophysis and its parts, and the body weight and body length, respectively, can be tested for significance in the same manner as for the means of the small groups[3] (Boyd, '33).

RESULTS

A. Weight of the whole hypophysis

As shown in tables 1, A,[4] the average weight of the whole hypophysis in the 'test castration' animals is greater than that of 'control I' group by 3.48 mg.; and table 1 B shows that the weights of 'castration complete' and 'epididymis intact' are 3.69 and 4.57 mg. greater than those of 'control II,' respectively. The result of combining the two control groups and the three test groups for purposes of comparison of larger samples, shows that the average weight of the whole hypophysis in the test animals is 4.05 mg. heavier than that of the control (table 1, C). All these differences are significant, since they could occur by chance, as indicated by $P \times 100$ in the table, less than once in a hundred times.

Inspection of the same tables shows that the difference between the weights of the hypophysis in the two experimental groups, i.e., 'castration complete' in which the epididymis had been removed and 'test castration'—'epididymis intact' in which the epididymis remained intact, would be less than

[3] The author wishes to thank Prof. A. T. Rasmussen for his helpful suggestions dealing with the morphological aspects of the problem; Dr. Edith Boyd, for her suggestions regarding the application of statistical methods.

[4] Only the average values of all computations are given in the tables. The records of the individual animals can be obtained from the Department of Anatomy, University of Minnesota, where they are filed.

two times its standard error, hence the two methods of castration had no significantly different effects on the weight of the gland.

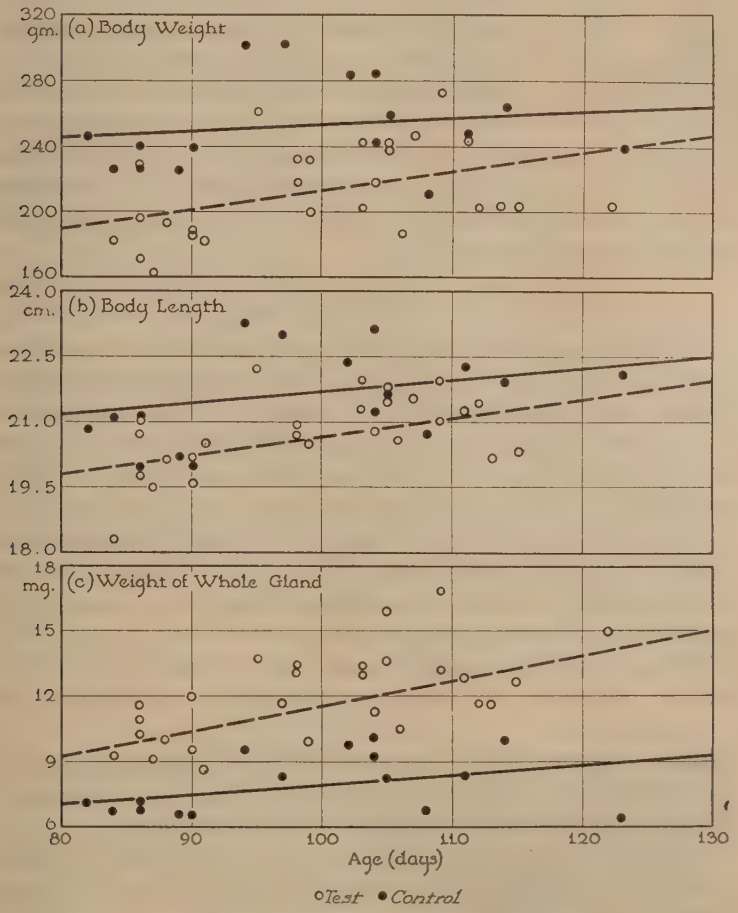

Fig. 1 Regression lines as predicted from age.

No significant difference (table 1, D) was found between the regression coefficients, i.e., the slope of the repression line, (fig. 1, c) for the whole weight of the hypophysis of the

control and the whole weight of the hypophysis of the test animals which indicates that there is a progressive increase in weight of the hypophysis in these 60- to 80-day castrated animals which parallels the rate of increase in the normal gland.[5] This is in agreement with the physiological findings of Evans and Simpson ('29), who note that the gonad-stimulating capacity of the hypophysis slowly increases up to the eight postoperative week, after which little increase is found. It is also in agreement with the cytologic reports of Schenk ('27 and '29), who finds progressive changes in cell types until a level is reached some time between the fourth and seventh postoperative months.

B. Absolute and relative volume of the lobes

The results of this part of the experiment are summed up in tables 2, A, B, and C, which give the average values of the lobes of the 'controls' and 'tests.' In referring to the statistical constants for these values, the following conclusions have been reached: there is a significant increase in the absolute and relative weight of the pars anterior in 'test castration' over 'control I' as seen in table 2, A; there is no significant change in the absolute weight of the pars intermedia and pars posterior in these two groups (table 2, A); but there is a relative decrease (table 2, A).

Similar conditions exist between the various lobes of 'control II' and those of 'castration complete'—'epididymis intact' (table 2, B).

Again inspection of the tables will show that total castration did not significantly alter the lobe changes as compared with those in which the testes alone were removed.

In comparing the lobe changes in the combined control groups and combined test groups (table 2, C), they are seen

[5] Although the apparently higher regression coefficient for the weight of the castrated rat hypophysis is not significant during this period, it must have been higher during the preceding period in order for the mean weight to be higher. For a larger sample the apparently greater rate would prove to be significant, i.e., the hypophysis is still increasing at a greater rate in the castrated animals than the non-castrated.

to be similar and equally as striking as when the groups were considered separately.

Since the pars anterior increased in absolute and relative weight, while the pars intermedia and pars posterior retained their absolute weight and showed a relative decrease in size, it is clear that the total increase in the weight of the whole hypophysis as a result of castration is due to an increase in size of the pars anterior.

The increase of the anterior lobe in the test animals with duration of castration as measured by the regression coefficient (table 2, D), and illustrated by the slope of the regression lines (fig. 2), shows a difference between it and the regression coefficient of the anterior lobe of the control animals which is 1.97 times the standard error of the difference.

No significant differences could be found between the slopes of the regression lines (table 2, D, and fig. 2) of the intermediate and posterior lobes of the control and test animals indicating that the increase in weight of these two lobes in the test glands paralleled the increase in the normal gland.

The weights of the parts of the gland as calculated from the regression line for age are added to each other on the same graph (fig. 2), both for the relative and absolute values. This graph illustrates the finding that only the anterior lobe of the hypophysis is enlarged by castration. This causes a relative decrease in the pars intermedia and posterior.

C. Colloid

A considerable amount of colloid was found in the lumen of the test glands varying from 0.2 to 5.0 per cent of the total weight of the gland. Only 6 of the 27 test glands had no colloid in them, while only 1 of the 16 control animals showed any colloid, and then only a slight trace.

D. Weight and length of animals

The mean weight and body length of the control animals are significantly greater than those for the castrated animals,

since the difference between the means of both weight and length are, respectively, 4.51 and 2.78 times the standard error of their difference (table 1, A, B, and C).

There is no significant difference, however, between the body weight and body length of the completely castrated animals and those with the epididymis left intact (table A and B).

In figure 1 a and b, body length and body weight have been plotted against age and their regression lines drawn in.

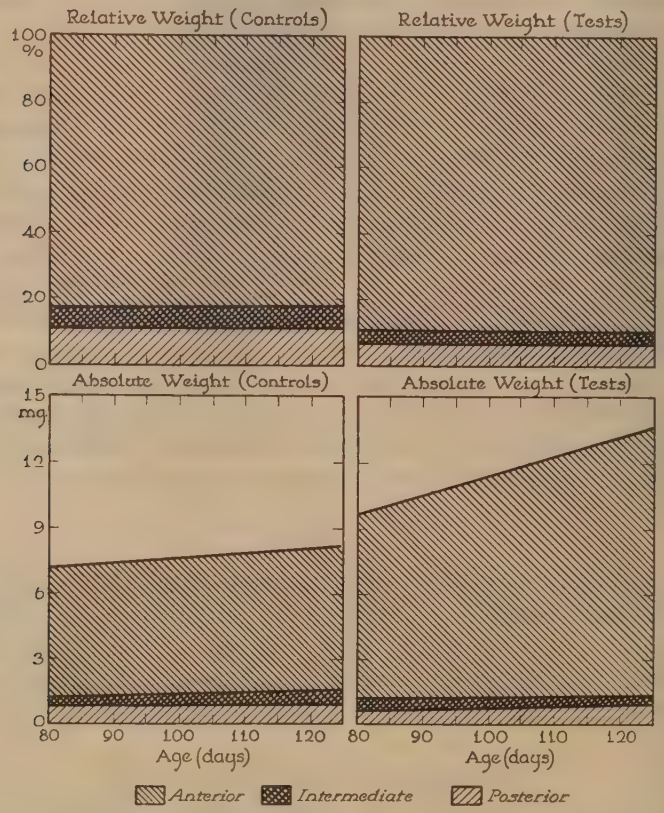

Fig. 2 The results of the absolute and relative weights of the test and control glands when their regression lines are added to each other, in the order that they appear in a cross section of the gland.

Although there is a considerable amount of overlapping, there is a definite tendency for the 'controls' and 'tests' to show separate groupings.

Table 1

Data for Weight of Whole Hypophysis, Body Weight, Body Length and Age of Control and Test Animals

Lobe	Animals	M ± S.E. m	Diff. ± S.E.diff.	Diff. / S.E.diff.	P (x 100)
A - Control I - Test Castration Groups					
Whole weight of hypophysis	Control I	7.39 ± .370			
	Test Cast.	10.87 ± .568	-3.48 ± .677	5.140	.0
Body weight (grams)	Control I	251.00 ± 11.075			
	Test Cast.	202.44 ± 10.620	+48.56 ± 15.329	3.168	1.5
Body length (cms.)	Control I	21.50 ± .423			
	Test Cast.	20.33 ± .388	+1.17 ± .574	2.038	4.2
Age (days)	Control I	88.50 ± 1.793			
	Test Cast.	88.88 ± 1.621	-.380 ± 2.416	.157	87.0
B - Control II - Castration Complete and Epididymis Intact Groups					
Whole weight of hypophysis	Control II	8.60 ± .514			
	Cast.Comp.	12.29 ± .621	-3.69 ± .806	4.578	.0
	Epidid.Int.	13.17 ± .725	-4.57 ± .888	5.146	.0
Body weight (grams)	Control II	254.00 ± 8.513			
	Cast.Comp.	215.45 ± 7.058	-38.55 ± 11.045	3.490	.0
	Epidid.Int.	222.57 ± 10.801	-31.43 ± 13.747	2.286	2.1
Body length (cms.)	Control II	22.00 ± .491			
	Cast.Comp.	20.90 ± .222	+1.10 ± .529	2.079	4.0
	Epidid.Int.	21.30 ± .859	+0.70 ± .972	.720	47.0
Age in days	Control II	109.00 ± 1.482			
	Cast.Comp.	105.63 ± 2.956	+3.37 ± 3.306	1.019	30.0
	Epidid.Int.	105.71 ± 1.837	+3.29 ± 2.360	1.394	16.0
C - Combined Control and Combined Test Groups					
Whole weight of hypophysis	Control	7.994 ± .351			
	Test	12.048 ± .392	-4.054 ± .526	7.707	.0
Body weight (grams)	Control	252.438 ± 6.905			
	Test	212.963 ± 5.365	+39.475 ± 8.744	4.514	.0
Body length (cms.)	Control	21.763 ± .271			
	Test	20.837 ± .211	+0.926 ± .333	2.781	.5
Age (days)	Control	98.688 ± 3.031			
	Test	100.074 ± 2.049	-1.386 ± 3.657	.379	70.0
D - "B" the Slope of the Regression Line as Predicted from Age					
		B ± S.E. B			
Whole weight of hypophysis	Control	.041 ± .029			
	Test	.115 ± .031	-.0734 ± .042	1.748	8.0
Body weight	Control	.330 ± .602			
	Test	1.139 ± .472	-.809 ± .764	1.058	29.0
Body length	Control	.030 ± .023			
	Test	.050 ± .018	-.020 ± .029	.685	50.0

There is no progressive difference between the body weight and body length of the control and test animals during this period of castration, since their regression coefficients are not significantly different from each other[6] (fig. 1 a, b, and table 1, D).

[6] Although the apparently higher regression coefficients for the body weight and body length of the control group are not significant during this period; they must have been higher during the preceding period in order for the mean body weight and body length of the control group to be greater than that of the test group.

E. Histology

Large atypical basophilic cells with various intermediate stages of development to the signet-ring or vacuolated castration cells can readily be seen in the sections of the test glands.

However, it would be necessary to make a differential cell count to determine whether or not there is an actual increase in number of these atypical basophils and castration cells in the test glands over the number of ordinary basophils in the normal gland, as has been claimed for the rat by Nukarija ('26), Schenk ('27) and Satwornitzkaja ('27). This assumes, of course, and as appears to be the case, that the castration cell is derived from the ordinary basophil. On general inspection there appear to be as many normal basophils in the control glands as there are atypical cells in the test glands. If this proves to be true, the increase in size of the gland would therefore be due to hypertrophy of cells rather than to hyperplasia. This is supported by the fact that no signs of mitosis are evident. A great variability in the number of these castration cells and of normal cells in the individual glands, as is regularly found in material of this sort (Stein, '33) would also necessitate a differential count to determine definitely if there is an actual change in their numbers.

Another striking cytologic feature in the test animals is the tremendous number of eosinophils. They appear to be present in considerably greater numbers than in the controls and seem to out-number the basophils.

Whether or not there are actually more of them in the test glands than in the normal glands awaits accurate differential counting.

Due to the presence of so many basophils and eosinophils, there appear to be relatively few neutrophils.

The findings in these test glands seems to agree with those of Lehman ('28), who made the following observations: marked increase in eosinophils, especially in late castrates; basophils slightly increased; and chromophobes decreased.

Table 2

Data for Absolute and Relative Weight of the Individual Lobes of the Test and Control Animals

Lobe	Animals	M ± S.E. m	Diff. ± S.E.diff.	Diff. / S.E.diff.	P (x 100)
A - Control I - Test Castration Groups					
Pars Anterior (absolute wt.)	(Control I	6.091 ± .361			
	(Test Cast.	9.422 ± .444	-3.331 ± .572	5.823	.0
Pars Intermedia (absolute wt.)	(Control I	.502 ± .033			
	(Test Cast.	.460 ± .057	+.042 ± .066	.636	53.0
Pars Posterior (absolute wt.)	(Control I	.792 ± .018			
	(Test Cast.	.829 ± .037	-.037 ± .041	.902	37.0
Pars Anterior (relative wt.)	(Control I	82.245 ± .847			
	(Test Cast.	86.721 ± .642	-4.376 ± 1.063	4.117	.0
Pars Intermedia (relative wt.)	(Control I	6.821 ± .383			
	(Test Cast.	4.175 ± .398	+2.646 ± .552	4.793	.0
Pars Posterior (relative wt.)	(Control I	10.917 ± .192			
	(Test Cast.	7.692 ± .325	+3.225 ± .377	8.554	.0
B - Control II - Castration Complete and Epididymis Intact Groups					
Pars Anterior (absolute weight)	(Control II	7.082 ± .423			
	(Cast.Comp.	10.773 ± .582	-3.691 ± .719	5.134	.0
	(Epidid.Int.	11.515 ± .664	-4.433 ± .787	5.633	.0
Pars Intermedia (absolute weight)	(Control II	.571 ± .064			
	(Cast.Comp.	.550 ± .039	+.021 ± .075	.280	78.0
	(Epidid.Int.	.538 ± .040	+.033 ± .075	.440	66.0
Pars Posterior (absolute weight)	(Control II	.948 ± .053			
	(Cast.Comp.	.884 ± .037	+.064 ± .065	.985	32.0
	(Epidid.Int.	.926 ± .049	+.022 ± .072	.306	75.0
Pars Anterior (relative weight)	(Control II	82.364 ± .454			
	(Cast.Comp.	87.526 ± .571	-5.162 ± .729	7.081	.0
	(Epidid.Int.	87.344 ± .946	-4.980 ± 1.048	4.752	.0
Pars Intermedia (relative weight)	(Control II	6.579 ± .524			
	(Cast.Comp.	4.524 ± .309	+2.055 ± .608	3.380	.0
	(Epidid.Int.	4.163 ± .408	+2.416 ± .664	3.638	.0
Pars Posterior (relative weight)	(Control II	11.057 ± .281			
	(Cast.Comp.	7.259 ± .240	+3.798 ± .369	10.292	.0
	(Epidid.Int.	7.169 ± .561	+3.888 ± .627	6.201	.0
C - Combined Control and Combined Test Groups					
Pars Anterior (absolute wt.)	(Control	6.587 ± .297			
	(Test	10.515 ± .354	-3.928 ± .452	8.690	.0
Pars Intermedia (absolute wt.)	(Control	.536 ± .037			
	(Test	.517 ± .028	+.019 ± .046	.413	70.0
Pars Posterior (absolute wt.)	(Control	.870 ± .034			
	(Test	.877 ± .023	-.007 ± .040	.018	98.0
Pars Anterior (relative wt.)	(Control	82.305 ± .458			
	(Test	87.211 ± .385	-4.906 ± .598	8.204	.0
Pars Intermedia (relative wt.)	(Control	6.700 ± .315			
	(Test	4.314 ± .206	+2.386 ± .376	6.346	.0
Pars Posterior (relative wt.)	(Control	10.987 ± .324			
	(Test	7.380 ± .046	+3.607 ± .327	11.031	0
D - "B" the Slope of the Regression Line as Predicted from Age		B ± S.E. B			
Pars Anterior (absolute wt.)	(Control	.033 ± .022			
	(Test	.102 ± .028	-.069 ± .035	1.975	5.0
Pars Intermedia (absolute wt.)	(Control	.004 ± .003			
	(Test	.006 ± .002	-.002 ± .004	.555	58.0
Pars Posterior (absolute wt.)	(Control	.002 ± .003			
	(Test	.006 ± .003	-.004 ± .004	.952	33.0
Pars Anterior (relative wt.)	(Control	.023 ± .040			
	(Test	.005 ± .038	+.018 ± .055	.327	74.0
Pars Intermedia (relative wt.)	(Control	.009 ± .029			
	(Test	.022 ± .019	-.013 ± .035	.375	70.0
Pars Posterior (relative wt.)	(Control	.014 ± .028			
	(Test	.005 ± .020	+.009 ± .034	.262	79.0

CONCLUSIONS

1. The average weight of the whole hypophysis in a group of castrated rats was significantly greater than the average weight of the whole hypophysis in a group of control animals.

2. A significant difference was found in the absolute and relative weights of the pars anterior of the test as compared with the control glands.

3. No significant difference occurred between the absolute weights of pars posterior and pars intermedia of the test and control glands, but a significant difference was found between the relative weights of these two parts in the test and control animals.

4. The increase in weight of the hypophysis in castration is therefore limited entirely to the anterior lobe.

5. A difference of 20 days in the duration of castration did not materially change the picture.

6. Removing the epididymis with the testis in the operative procedure gave the same results as leaving the epididymis intact.

7. An accumulation of colloid varying from 0.2 to 5.0 per cent of the total weight of the gland was found in the test glands. Practically none was seen in the control glands.

8. A significant decrease in body weight and body length was noted in the test animals.

9. Preliminary inspection of the sections shows many large basophilic castration cells, a great number of eosinophils, and a relatively small number of neutrophils. More accurate determination awaits a differential cell count.

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ON WEIGHT-BEARING BONY PROMINENCES

FREDERIC WOOD JONES
Melbourne
Department of Anatomy, Peiping Union Medical College, Peiping, China

It is a general rule that where, in the animal body, a bony prominence is subjected to pressure from without the body, a very definite anatomical picture is presented. A pad of fibrous tissue intervenes between the bony prominence and the skin that covers it, and in this fibrous tissue a bursa may be developed or fat may be enmeshed.

A bony prominence upon which the body weight is borne in any of the animal's habitual postures has, as a rule, no structures, save fibrous tissue, bursal spaces, and fat, intervening between it and the skin that covers it. In former days the surgeon who had amputated a leg felt impelled to cover the weight-bearing end of the divided bone with a pad derived from the muscles of the limb; and this was done in mistaken kindness. Most surgeons nowadays realize that in the construction of a muscle pad to cover the end of the bone they are not imitating nature, but are handicapping the patient by giving him a redundant and unstable extremity for his stump. In connection with this question of the covering of weight-bearing prominences there arises the problem to which Elftman (American Journal of Anatomy, vol. 51, no. 2, p. 307) has devoted his attention. The following quotations are taken from his paper.

Even in the sitting posture man exhibits peculiarities of his own. He possesses no ischial callosities and no anal cushion. Instead, the gluteus maximus is furled over the ischial tuberosity, cushioning man when he assumes the sitting position. This particular disposition of the gluteus maximus is also of extreme importance in locomotion. It is impossible

to tell which function was more important in giving it survival value (p. 309).

In man the most impressive feature in the sitting position is the intervention of the gluteus maximus between the ischial tuberosity and the substratum. The great trochanter assists the ischial tuberosity in broadening the base of support, especially when the femur is rotated outward. It is noticeable that corpulent people like to sit with their knees widely spread (p. 314).

If this were so, the tuberosity of the ischium would be an exception to the general rule that muscle masses do not intervene between weight-bearing bony prominences and the skin that covers them. But in order to sit down a man flexes his thigh at the hip joint and, with this act of flexion, the lower margin of the gluteus maximus is carried upward and the lower portion of the ischial tuberosity, upon which he sits, fulfills the conditions of a weight-bearing prominence that prevail generally in the animal body. The human form of the gluteus maximus is very definitely related to the maintenance of the erect posture upon a fully extended thigh, which is, after all, the distinction of human uprightness; but its cushioning function would be anatomically anomalous. That corpulent people like to sit with their legs wide apart is perhaps capable of a simpler explanation than that involved in supposing the weight to be carried on the great trochanters.

PREGNANCY CHANGES IN THE ANTERIOR HYPOPHYSIS OF THE ALBINO RAT [1]

J. M. WOLFE AND RUCKER CLEVELAND

Departments of Anatomy and Gynecology, Vanderbilt University School of Medicine, Nashville, Tennessee

TWO FIGURES

Comte (1898) found that, during pregnancy in the human, the anterior hypophysis underwent a marked increase in size. He attributed this hypertrophy to an increase in the number of cells. Later, Erdheim and Stumme ('09) found that, throughout the course of pregnancy in the human, there was a progressive decrease in the relative number of eosinophiles and basophiles in the anterior hypophysis. Coincident with this relative decrease in granular cells, there was an increase in the relative number of the chief, or chromophobe cells, which, however, became somewhat altered, giving rise to the so-called pregnancy cell, or 'Schwangerschaftszellen.' The chief feature of the alteration of the chief cells was an increase in the amount of cytoplasm.

Since this pioneer work, many investigators have described changes occurring during pregnancy in the hypophyses of many species. Most of these workers agree that during pregnancy a specialized cell type is found, but there is little definite information concerning the origin or the nature of these cells. Kolde ('12), Berblinger ('14), Lehmann ('27), and Baniecki ('28) regard these cells as altered chromophobes or chief cells, while Kraus ('14) looks upon them as specialized eosinophiles. Lehmann and Baniecki also report that, throughout the course of pregnancy, there is a relative de-

[1] This work has been aided by a grant from the National Research Council Committee for Research in Problems of Sex.

crease in the number of eosinophiles. Reese ('32) describes the pregnancy cell as 'a modified acidophile' which is pale and enlarged. Haterius also ('32) describes the pregnancy cells as altered eosinophiles. Furthermore, he found the same type of cells in the anterior pituitaries of lactating and pseudopregnant rats. From this brief consideration of the literature, it is obvious that the origin of these cells is in question. Moreover, most investigators who have studied hypophyses from pregnant animals have been concerned only with the so-called pregnancy cells and hence certain other changes which occur during pregnancy have not been considered.

In a recent paper, Swezy and Evans ('30) describe cyclic histological changes in the ovaries of pregnant rats. These investigators found waves of follicular growth in the ovaries which were comparable to those occurring in the normal cycle of non-pregnant rats. These follicles did not rupture, but underwent direct luteinization, producing corpora lutea which were usually about one-third as large as the corpora lutea of pregnancy. In view of our recent work (Wolfe and Cleveland, '33) on the histology of the anterior pituitary of the normal albino rat at the different phases of the oestral cycle, we have thought it of interest to study the hypophyses of albino rats in various selected stages of pregnancy in order to detect any characteristic histological variations. In addition, we have studied the anterior hypophyses of a limited number of rats killed in pseudopregnancy. The animals used in these experiment had not previously been pregnant or pseudopregnant.

Anterior lobe tissue and the reproductive organs were obtained from rats[2] sacrificed at daily intervals from the first through the twenty-first days of pregnancy. Although tissue was obtained from animals at each day of pregnancy, it was found advantageous to divide the period of gestation into three equal parts and to consider together the tissue of those

[2] Since it has been found in work on the cyclic histological changes in the anterior hypophyses of non-pregnant animals that the cell types varied in the different species studied, we have also studied material from pregnant and pseudopregnant rabbits and from pregnant guinea pigs. A limited amount of material from pregnant dogs, cats, and humans has also been studied.

animals that belonged in each of the respective thirds. Material was also collected from nineteen rats killed at daily intervals from the second through the eleventh day of pseudopregnancy. Tissue taken from animals during the first seven days of pseudopregnancy was considered as one unit and tissue from the eighth through the eleventh day as another.

The technical methods used in the preparation of the anterior lobe material for study have already been described in a general way (Cleveland and Wolfe, '32). The original method was modified in the following particulars: All anterior lobes used in these studies were cut serially in the horizontal plane at 1.5 to 2 μ. One section from near the middle of each ribbon of twenty-five was mounted and stained. Cell counts were made on every fifth field of each section studied. Table 1 shows the number of sections studied from each gland and the total number of cells counted.

CELL TYPES IN THE ANTERIOR HYPOPHYSIS OF THE RAT

Two granular and one non-granular cell types were found in the anterior hypophysis of the rat. In a previous paper (Wolfe and Cleveland, '33), we have classified the eosinophilic cells as cells of type I, while the basophilic elements were classified as cells of type III. The non-granular cells, chromophobes, were classified as cells of type IV. In the same studies referred to above, it was found that there are definite cyclic changes in the hypophysis of the normal unmated rat. However, if we consider the group of material as a whole, the cells of type I averaged 32.7 per cent, the cells of type III, 4.9 per cent, and the cells of type IV, 62.4 per cent.

THE ANTERIOR HYPOPHYSES OF RATS KILLED DURING THE FIRST THIRD OF PREGNANCY

By the third day of pregnancy, the gland was definitely swollen and hyperemic. The capillaries were tremendously distended and the cell cords were rather loosely arranged in the gland. The cells of type I were considerably enlarged. The granules which were rather fine were loosely arranged in the cells and took a pale stain with orange G. Many of

TABLE 1

Relative percentages of cell types of the anterior hypophyses of rats during pregnancy

PHASE		TYPE I	TYPE III			TYPE IV	GLANDS STUDIED	SECTIONS COUNTED	CELLS COUNTED
			Granular	Non-granular	Total				
Proœstus[1]		32.8	3.8	1.2	5.0	62.2	6	30	16,523
Oestrus		31.7	1.4	4.7	6.1	61.2	11	50	36,054
Pregnancy, day	*Animal No.*								
2	P-22	27.4	..	3.1	3.1	69.5	1	6	4,984
3	P-14	33.3	1.2	3.5	4.7	62.0	3	5	2,482
	P-112	24.3	1.2	2.2	3.4	72.3		5	3,805
	P-114	27.2	..	4.3	4.3	68.5		4	2,870
4	P-20	22.7	1.2	0.6	1.8	75.5	1	6	5,007
5	P-5	24.1	2.7	1.5	4.2	71.7	2	5	3,525
	P-103	27.0	2.1	1.9	4.0	69.0		5	3,462
6	P-10	29.2	3.7	0.4	4.1	66.7	2	6	4,833
	P-109	26.6	2.8	0.6	3.4	70.0		5	3,172
7	P-25	29.4	1.4	1.2	2.6	68.0	1	5	5,017
Average for first third of pregnancy		27.1	1.6	1.9	3.5	69.4	10	52	39,157
8	P-19	28.9	3.3	2.4	5.7	65.4	2	7	4,087
	P-107	31.0	1.3	0.4	1.7	67.3		5	4,424
9	P-1	28.0	2.5	0.3	2.8	69.2	2	5	2,702
	P-100	31.6	3.0	0.6	3.6	64.8		4	3,326
10	P-23	30.8	3.4	0.6	4.0	65.2	2	4	3,434
	P-119	37.0	2.6	0.4	3.0	60.0		4	3,951
11	P-15	26.7	2.2	0.1	2.3	71.0	1	5	4,150
12	P-7	34.3	2.7	..	2.7	63.0	2	4	2,554
	P-118	38.0	2.9	0.4	3.3	58.7		5	3,250
13	P-24	36.0	2.9	..	2.9	61.1	2	6	4,523
	P-132	30.0	4.7	..	4.7	65.3		5	2,260
14	P-8	34.1	0.5	1.8	2.3	63.6	2	7	6,743
	P-99	26.4	4.8	0.6	5.4	68.2		5	2,729
Average for second third of pregnancy		31.7	2.9	0.5	3.4	64.9	13	66	48,133
15	P-4	31.5	3.4	..	3.4	65.1	2	5	3,028
	P-97	32.9	5.6	..	5.6	61.5		4	4,444
16	P-6	31.8	3.3	0.9	4.2	64.0	1	4	3,832
17	P-16	35.4	3.4	..	3.4	61.2	1	5	4,705
18	P-17	35.1	2.8	0.3	3.1	61.8	3	4	5,889
	P-106	35.2	4.0	..	4.0	60.8		4	2,954
	P-113	31.5	3.7	..	3.7	64.8		4	2,779
19	P-11	36.5	2.1	0.6	2.7	60.8	2	4	3,277
	P-117	28.7	3.7	0.2	3.9	67.4		4	3,059
20	P-3	34.6	3.4	0.2	3.6	61.8	3	4	3,932
	P-102	30.1	5.4	..	5.4	64.5		4	2,480
	P-108	31.0	3.7	..	3.7	65.3		6	4,923
Average for last third of pregnancy		32.8	3.7	0.2	3.9	63.2	12	52	45,302
21	P-13	33.1	4.8	1.4	6.2	60.7	2	4	4,578
	P-115	31.4	4.0	1.2	5.2	63.4		5	3,252
Average for 21st day of pregnancy		32.2	4.4	1.3	5.7	62.0	2	9	7,830

[1] See footnote under table 2.

these cells exhibited an extreme reduction in granular material. In many cells of type I the nucleus was surrounded by only a few pale yellow granules. In such cells the cell membrane was usually indistinct.

The impression gained was that during this phase cells of type I were losing their granular material and passing into cells of type IV. The average percentage of these cells during this phase of pregnancy was only 26.9 (table 1), while in non-pregnant rats, killed in oestrus, these cells averaged 32.7 per cent. Coincident with this decrease in cells of type I there was an increase in the cells of type IV. In non-pregnant rats, killed in oestrus, they averaged 62.4 per cent; in pregnant rats killed during the first third of pregnancy they averaged 69.6 per cent. One point must be emphasized; in the anterior hypophyses of non-pregnant rats killed during the normal cycle, we never observed any considerable number of cells of type I in which the reduction of granular material was marked. This is in direct contrast to the condition found in these cells in early pregnancy. In this connection it must be remembered that in the rat the corpora lutea do not become active during the normal cycle, while in early pregnancy the corpora lutea are active.

The cells of type III were not unusual. During the first 3 days of pregnancy, those which did not contain granular material were relatively abundant. However, from this time to the end of pregnancy, the non-granular form of the cells of type III was rarely found. Those which contained granules appeared in appreciable numbers on the fourth and fifth days of pregnancy. From this time throughout pregnancy, the granular forms of these cells were quite abundant. The granular type III cells found in this period were similar in size and staining reaction to those found in non-pregnant rats. Table 1 shows the relative percentage of these cells during this period.

THE ANTERIOR HYPOPHYSES OF RATS KILLED DURING THE SECOND THIRD OF PREGNANCY

The cells of type I differed both qualitatively and quantitatively from those of the first third of pregnancy. The large cells in which the granular content was reduced were less numerous, while many smaller cells of this type were observed. The closely packed granular material of the small cells stained intensely with orange G, while the more loosely packed granules of the larger cells stained less intensely. The cells of type I were also more abundant, increasing in average percentage from 26.9 to 31.6. There was a coincident drop in the average percentage of the cells of type IV found (table 1).

The changes in the cells of type III were even more marked. There were practically no cells of this type found which did not contain granules. The cells of type III containing granules were much larger than those found in non-pregnant animals. They were usually closely packed with granules. They were especially abundant on the periphery of the gland and in the most anterior portion.[3] The staining reaction was also changed. In non-pregnant rats the granules of these cells usually stained a deep blue. In this phase of pregnancy the granules of the cells took up erythrosin as well as aniline blue, the resulting color of the granules varying from violet to brick-red (most of them were violet). Most of these cells were intact, although in some the granular material was scattered and the cell membrane was invisible. In such instances the granules usually took a lighter stain.

THE ANTERIOR HYPOPHYSES OF RATS KILLED IN THE LAST THIRD OF PREGNANCY

The cells of type I, found during this phase of pregnancy, were, for the most part, well filled with granular material. The larger cells of type I in which the granular content was reduced were in a minority. The cells of type I were slightly more abundant than in the preceding period (table 1).

[3] It is in this area of the anterior hypophyses of normal dogs and sows and of ovariectomized rats that the basophilic elements are most abundant.

The cells of type III were also more abundant than in the preceding phase of pregnancy. In appearance they were quite similar. There was no evidence of granular loss from these cells, except on the twenty-first day of pregnancy. On this day we found typical cells of type III which did not

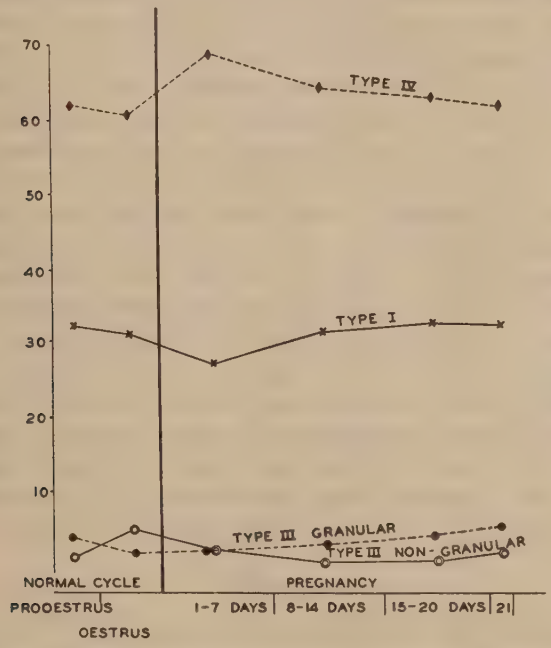

Chart 1 Graphic representation of the quantitative changes occurring in the anterior hypophysis during pregnancy. The percentages of the various cell types are indicated on the ordinate, while the days of pregnancy are indicated on the abscissa.

contain granular material, i.e., large cells with clear blue cytoplasm. It is interesting to note that anterior lobes taken from rats on the twenty-first day of pregnancy were quite similar to those of rats in prooestrus. In this connection it should be remembered that rats come into oestrus soon after delivery. The quantitative changes found in pregnancy are summarized in chart 1.

CHANGES IN THE ANTERIOR HYPOPHYSIS DURING PSEUDOPREGNANCY

Material from animals killed during the first 11 days of pseudopregnancy was studied. As far as we have been able to discern, the changes during early pseudopregnancy are in every way similar to those found in pregnancy. During the first few days following ovulation there was evidence of granular reduction in the cells of type I. The relative percentage of these cells was also reduced (table 2). There was a coincident increase in the relative percentage of the cells of type IV. After the sixth or seventh day of pseudopregnancy, this loss of granular material from the cells of type I was much less in evidence. From the seventh to the eleventh day of pseudopregnancy many small cells of type I were found. The changes in the cells of type III were also similar to those found in pregnancy. During the first few days after ovulation, cells of this type were found which did not contain granular material. After the sixth or seventh day of pseudopregnancy, large cells of type III were found which were completely filled with basophilic granules, staining a violet or purple red. Table 2 gives the details of counts made on anterior lobe material from these animals. The quantitative changes occurring in pseudopregnancy are summarized in chart 2.

DISCUSSION

Examination of the literature reveals the fact that most investigators have regarded pregnancy cells as hypertrophied chief cells (our type IV). In the excellent plates of Erdheim and Stumme ('09), the pregnancy cells are shown as large groups of nuclei surrounded by a mass of non-granular cytoplasm. These groups of nuclei usually fill an entire alveolus. No cell boundaries are evident. It seems possible that they were dealing with a large number of chromophobes or chief cells which were grouped closely together in an alveolus, giving the impression of a large multinucleated cell. In another plate they picture these cells as containing a few scattered granules, but these granules are apparently identical with

those found in the eosinophilic cells at the periphery of the same alveolus. No cells resembling the pregnancy cells described by Erdheim and Stumme have been found in the ante-

TABLE 2

Relative percentages of cell types of the anterior hypophyses of rats during pseudopregnancy

PHASE		TYPE I	TYPE III			TYPE IV	GLANDS STUDIED	SECTIONS COUNTED	CELLS COUNTED
			Granular	Non-granular	Total				
Prooestrus[1]		32.8	3.8	1.2	5.0	62.2	6	30	16,523
Oestrus		31.7	1.4	4.7	6.1	61.2	11	50	36,054
Pseudo-preg-nancy, day	*Animal No.*								
2	Ps-400	27.4	..	3.5	3.5	69.1	1	4	2,261
3	Ps-25	25.5	..	2.5	2.5	72.0	2	5	2,688
	Ps-401	25.8	..	2.5	2.5	71.7		4	3,561
4	Ps-116	25.5	1.5	1.5	3.0	71.5	1	5	3,221
5	Ps-397	20.0	..	1.6	1.6	78.4	1	4	3,156
6	Ps-17	30.3	1.4	3.3	4.7	65.0	1	4	3,184
7	Ps-18	28.9	2.9	..	2.9	67.8	4	4	4,177
	P-18	23.7	1.4	0.9	2.3	74.0		5	2,488
	Ps-120	28.0	1.0	0.7	1.7	70.3		5	4,365
	Ps-105	29.2	3.0	1.0	4.0	66.8		5	2,915
Average first 7 days of pseudo-pregnancy		26.4	1.2	1.7	2.9	70.7	10	45	32,016
8	Ps-15	30.2	4.0	..	4.0	65.8	3	4	3,234
	Ps-11	46.4	8.1	..	8.1	45.5		5	3,820
	Ps-330	31.6	2.7	..	2.7	65.7		6	3,579
9	Ps-323	26.3	2.2	..	2.2	71.5	3	5	6,036
	Ps-9	34.6	4.4	..	4.4	61.0		3	2,929
	Ps-10	29.6	6.3	..	6.3	64.1		4	3,727
10	Ps-2	35.4	3.2	..	3.2	61.4	2	5	3,575
	Ps12	44.0	4.0	..	4.0	52.0		4	4,076
11	Ps3	41.8	4.6	..	4.6	53.6	1	5	4,972
Average for eighth to eleventh days of pseudo-pregnancy		35.5	4.4	..	4.4	60.0	9	41	35,948

[1] The percentages of the cell types found in the anterior hypophyses of the non-pregnant rats killed in prooestrus and oestrus are given here for comparison with the percentages of these cells found during pregnancy and pseudopregnancy.

rior hypophysis of the pregnant rat, although one does see a tremendous number of cells of type IV (chromophobes or chief cells), either grouped together or scattered throughout

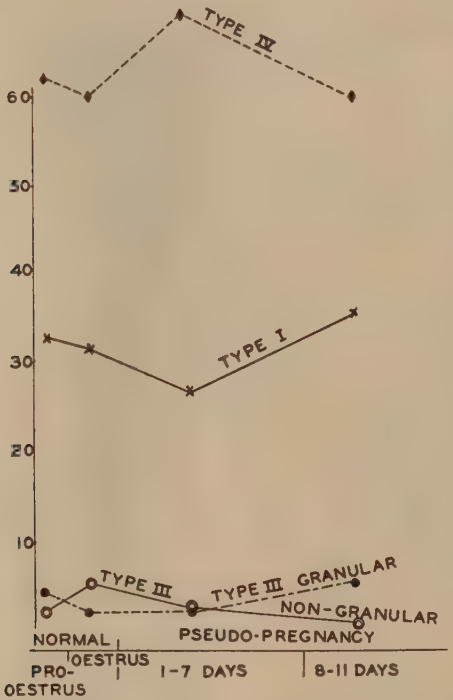

Chart 2 Graphic representation of the quantitative changes occurring in the anterior hypophysis during pseudopregnancy. The percentages of the various cell types are indicated on the ordinate, while the days of pseudopregnancy are indicated on the abscissa.

the gland. However, in the rat we do not find the alveolar arrangement of the cells; but this arrangement is found in the anterior hypophyses of pregnant cats, sows, guinea pigs, and humans.[4] In these animals, as well as in pregnant rats,

[4] The human anterior lobe tissue referred to in these studies was collected through the courtesy of Drs. M. Halpern and T. A. Gonzales, of the Medical Examiners Board of New York City. A detailed report of this material will be published later.

the cells of type I (eosinophiles) exhibit a partial reduction of granules. These cells are usually considerably enlarged. The granules which remain in the cells are usually distributed irregularly in the cell and take a pale stain with orange G. During pregnancy, in the hypophyses of the animals in which we find the alveolar arrangement of the cells, the cells of type I are usually found on the periphery of an alveolus, while the cells of type IV are found in the center. Many alveoli may be observed in which only one or two of the type I cells are present, the rest of the alveolus being packed with cells of type IV. A few pale eosinophilic granules were often observed among the cells of type IV. The impression gained was that the cells of type I had lost their granular material and had given rise to the non-granular cells of type IV. The result was that entire alveoli were observed which contained only type IV cells. The cells of type III (basophiles) also exhibited marked evidence of loss of granular material, thus giving rise to the cells of type IV. The alveoli completely or almost completely filled with the type IV cells were almost identical in appearance to the pregnancy cells pictured by Erdheim and Stumme (their pl. 1, figs. 3 and 4). The authors suggest that pregnancy cells are in reality only large groups of cells of type IV (chromophobes or chief cells), which appear in large numbers during this period.

Other workers (Kraus, '14; Reese, '32; and Haterius and Charipper, '32) have considered the pregnancy cell as a modified eosinophilic cell. In observations made on the anterior lobes of rats, guinea pigs, sows, and humans, we have found that during pregnancy the eosinophiles (our type I) undergo a reduction of granular material. During early pregnancy the granular material that remains in the cell is fine and takes a pale stain with orange G. These cells become enlarged or swollen. The cell membrane is often indefinite. However, such cells are not characteristic of pregnancy only, but are invariably found when the ovary of the animal contains active corpora lutea, regardless of whether the animal is or is not pregnant. Thus, such cells are found in the anterior lobes of

pseudopregnant rats, a finding already reported by Haterius ('32). Cells of type I of this nature have also been found in the anterior hypophyses of non-pregnant dogs, sows, and rabbits killed in the lutein phase of the cycle. In the opinion of the authors, a specialized cell, characteristic only of pregnancy, does not occur.

SUMMARY AND CONCLUSIONS

1. During the first part of pregnancy the cells of type I exhibited a reduction in granular material. They became somewhat enlarged and took a pale stain with orange G. There was a marked drop in the relative percentage of the cells of type I during this period. There was a coincident rise in the cells of type IV. During the middle and latter portions of pregnancy there was a gradual rise in the cells of type I, paralleled by a drop in the cells of type IV.

2. The cells of type III were enlarged in the latter two-thirds of pregnancy. They were well filled with granules which took a violet stain of varying shades. Cells of type III which did not contain granules were found during the first 3 days of pregnancy. From that time they were only infrequently observed until the twenty-first day, when they were found in moderate numbers.

3. No 'specialized pregnancy cell' was observed.

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VARIABILITY IN BODY LENGTH, BODY WEIGHT, AND ORGAN WEIGHTS OF THE RAT[1]

CLAY B. FREUDENBERGER
Department of Anatomy, University of Utah, Salt Lake City

Jackson ('13) made a rather extensive study of the variability of the body and the various organs in the albino rat. The albino rats which he used were obtained from various fanciers and fed a varied diet. A supply of chopped corn was kept constantly in the cages, a liberal amount of wheat bread soaked in whole milk was supplied daily, and fresh meat (beef) once a week. While it would seem that this diet should contain the essentials for good nutrition, it is well known that the rat thrives much better on our more modern diets. The rats which I have used in the present study are from strains which have been caged and well cared for for many years. It is of interest to see how domestication, close breeding, a well-balanced diet, and excellent care for a number of years will affect the variability.

MATERIALS AND METHODS

Rats of both the Wistar albino and the Long-Evans hybrid strain were used. All rats were given the same excellent care and fed the same diet. The diet consists of: casein, 15 per cent; whole milk powder, 10 per cent; sodium chloride, 0.8 per cent; calcium carbonate, 1.5 per cent; butter (unsalted), 5.2 per cent; and whole ground wheat, 67.5 per cent. A constant supply of the diet was kept in the cages, and a constant supply of clean tap water was provided.

[1] Contribution from the Department of Anatomy, University of Minnesota, Minneapolis, and from the Department of Anatomy, University of Utah, Salt Lake City.

All young weighing less than 35 gm. were usually discarded at weaning time (3 weeks). Five hundred and eighty-five rats were completely autopsied with organ weights, and forty-five other animals were incompletely autopsied to get certain organ weights to fill out incomplete groups. Animals were autopsied at birth and (approximately) at 3 weeks, 12 weeks, and 1 year of age.

The number of rats of each sex, strain, and age group (30 to 50 in each group) was given in detail in a previous paper (Freudenberger, '32). The details as to the origin of the two strains of rats used, method of autopsy, etc., were also given in the paper just mentioned, so they will not be repeated here.

The stomach and intestines (with their contents), mesentery, and pancreas are spoken of as the 'alimentary group.'

OBSERVATIONS

The coefficients of variation for body length, body weight, and each of the organ weights are given in tables 1 and 2. The probable error of each coefficient has been computed, but they are not included in the tables. Since there are no consistent sex differences, the values for the two sexes have been averaged in the following discussion.

Body length

Variability in body length for the Wistar strain is lowest at 3 weeks (the coefficient being 2.9) and is only slightly higher at 12 weeks (3.2). Body length is more variable at 1 year (3.6) and is most variable in the newborn group (4.7). The situation is different in the case of the Long-Evans strain. Here, variability in body length appears highest at 3 weeks (4.2), and it is only slightly less in the newborn group (4.0). It is lowest at 12 weeks (2.9). The coefficient at 1 year is the same as it was for the Wistar strain at the same age (3.6).

The chief difference in the variability in body length between the two strains is at 3 weeks, the body length in the Wistar strain being least variable at this age and the body

TABLE 1

Coefficients of variation in the Wistar strain

	NEWBORN		THREE WEEKS		TWELVE WEEKS		ONE YEAR		AVERAGE
	Males	Females	Males	Females	Males	Females	Males	Females	
Body length	5.92	3.50	4.16	1.64	3.57	2.86	4.29	2.85	3.60
Body weight	9.85	7.65	13.00	9.04	9.77	6.71	14.13	9.94	10.01
Head	9.10	10.43	6.83	5.16	8.41	5.45	9.53	6.09	7.63
Integument	13.92	8.07	13.28	12.62	12.95	5.72	15.39	10.80	11.59
Humerus	11.91	11.54	7.63	7.49	8.02	5.12	9.92	7.74	8.67
Femur	17.75	16.06	13.48	9.41	9.02	6.70	10.90	9.65	11.62
Brain	8.57	9.55	3.57	3.61	4.17	3.56	4.46	4.78	5.28
Spinal cord	12.95	10.32	6.35	6.34	7.67	6.75	7.19	5.35	7.87
Eye balls	12.75	11.51	4.07	4.29	3.95	3.89	3.51	2.37	5.79
Hypophysis	33.73	30.76	15.46	18.36	14.32	13.77	17.48	19.46	20.42
Suprarenals	20.20	18.25	15.35	9.58	8.48	15.11	12.74	19.68	14.92
Thyroid	....	....	16.68	21.99	24.84	17.07	18.89	21.92	20.40
Thymus	19.43	21.51	17.98	16.56	26.89	18.01	39.73	31.46	23.95
Alimentary group	47.78	57.45	20.81	17.81	15.88	13.07	18.99	17.47	26.16
Stomach	24.82	20.08	14.32	12.07	9.78	11.62	13.10	10.60	14.55
Intestines	22.64	21.92	19.85	16.84	15.58	15.84	17.46	13.20	17.92
Submaxillary glands	15.06	14.13	12.66	11.93	11.00	9.36	16.70	10.96	12.73
Liver	12.27	9.81	12.49	8.58	15.26	10.45	17.32	15.12	12.66
Spleen	33.39	27.16	25.83	18.32	13.68	11.60	21.58	17.05	21.08
Kidneys	18.45	15.77	15.89	11.33	13.66	10.17	12.98	12.71	13.87
Heart	18.07	21.47	14.48	12.68	11.89	7.23	12.11	11.57	13.69
Lungs	15.36	10.56	11.98	8.02	10.37	17.60	42.42	43.01	19.92
Ovaries	....	21.81	....	11.09	....	13.85	....	28.75	18.88
Uterus	....	....	....	12.09	....	26.37	....	27.39	21.95
Testes	17.16	....	18.98	....	11.74	....	17.89	....	16.44
Epididymides	....	....	15.22	....	20.35	....	17.50	....	17.69
Average of viscera	18.99	17.64	14.19	11.98	13.15	12.49	17.30	17.38	

TABLE 2

Coefficients of variation in the Long-Evans strain

	NEWBORN		THREE WEEKS		TWELVE WEEKS		ONE YEAR		AVERAGE
	Males	Females	Males	Females	Males	Females	Males	Females	
Body length	4.07	3.99	4.30	4.06	2.70	3.01	3.60	3.57	3.66
Body weight	7.31	5.74	9.05	12.19	9.28	7.88	16.19	12.13	9.97
Head	7.99	11.19	5.18	7.01	7.21	6.11	9.62	6.86	7.65
Integument	8.44	12.93	12.04	15.14	10.45	10.52	16.50	15.30	12.67
Humerus	7.11	13.52	8.98	7.92	8.07	7.91	12.86	10.25	9.58
Femur	14.11	14.68	9.23	10.73	9.92	8.56	14.71	10.64	11.57
Brain	6.44	6.06	3.76	4.46	3.76	5.51	4.88	4.02	4.86
Spinal cord	9.22	10.79	11.90	7.41	7.57	7.48	7.19	5.97	8.44
Eye balls	11.28	11.31	6.78	6.60	4.72	5.15	3.61	6.12	6.95
Hypophysis	38.74	43.29	17.60	15.92	12.24	13.70	13.44	21.26	22.02
Suprarenals	15.87	15.83	14.11	13.35	16.17	16.06	14.77	21.45	15.95
Thyroid	....	....	31.57	24.39	18.33	23.04	38.60	21.62	26.26
Thymus	15.74	17.62	19.28	18.92	23.35	19.60	27.43	51.72	24.21
Alimentary group	34.77	39.58	18.99	16.86	16.41	14.82	23.19	19.87	23.06
Stomach	14.25	13.08	14.08	11.52	13.95	17.57	17.40	17.19	14.88
Intestines	19.19	14.33	15.73	12.22	17.10	12.22	16.52	24.33	16.46
Submaxillary glands	15.25	12.84	15.75	15.22	14.99	16.32	16.73	13.60	15.09
Liver	15.43	12.30	12.32	16.10	14.60	16.92	25.47	28.31	17.68
Spleen	17.70	27.76	20.95	27.60	19.14	13.74	17.90	19.45	20.53
Kidneys	11.11	12.05	12.83	12.08	12.42	11.70	17.81	19.75	13.72
Heart	9.95	7.59	16.61	16.61	12.10	11.57	16.15	19.36	13.74
Lungs	10.59	16.71	9.18	13.08	19.35	12.79	32.95	35.43	18.76
Ovaries	....	22.21	....	21.02	....	18.92	....	37.89	25.01
Uterus	....	....	....	19.94	....	26.33	....	28.70	24.99
Testes	16.32	....	20.47	....	11.52	....	12.77	....	15.27
Epididymides	....	....	22.82	....	20.66	....	14.93	....	19.47
Average of viscera	15.14	16.25	15.63	15.08	14.23	14.62	17.56	22.13	

length in the Long-Evans strain being most variable. As has been shown by Freudenberger ('32), the Long-Evans animals grow much more poorly from birth to 3 weeks of age than they do later. This may account for some of the high variability in body length at 3 weeks of age in the strain. The mean coefficient of variation for body length (all age groups combined) is 3.6 in the Wistar strain and 3.7 in the Long-Evans strain.

Body weight

Variability in body weight for the Wistar strain is lowest at 12 weeks (the coefficient being 8.2) and is only slightly higher at birth (8.8). It appears highest at 1 year (12.0) and is only slightly less at 3 weeks (11.0). In the Long-Evans strain, variability in body weight is lowest at birth (6.5) and is highest at 12 weeks (8.6). It is highest at 1 year (14.2) and slightly less at 3 weeks (10.6).

Jackson ('13) found variability in the body weight of the albino rat to be lowest at birth and highest at 3 weeks. This agrees fairly well with these results. The highest variability in this study was found to be at 1 year. However, Jackson did not have any figures for rats at this age. Although variability in body weight of the Wistar animals was found to be less at 12 weeks than at birth, the difference in the coefficients is very small (statistically insignificant).

The mean coefficient of variation for body weight (all ages combined) was found to be 19 by Jackson. In this study the mean coefficient of variation for body weight is 10 in the case of both strains. Thus, the animals used in this study are only about one-half as variable in body weight as those studied by Jackson. This is probably due to the more homogeneous stock and more uniform environment in the present colony of rats.

The results of this study do not agree with those of King ('15), since she found variability in body weight of the Wistar albino rat to be greatest at 60 days. They do agree more closely with King's results than those of Jackson as to degree

of variability for the body weight in general. She found the mean coefficient of variation (all ages) for the male rats to be 13.6 and that for the females to be 12.1. The mean coefficient of variation for the body weight (four age groups combined) for our Wistar males is 11.7; Wistar females, 8.3; Long-Evans males, 10.5; and Long-Evans females, 9.5. These results also agree well with those of Smith and Bing ('28), who found the mean coefficient of variation for body weight at all ages for albino rats to be 11.9 for the males and 10.5 for the females. Jackson ('13) likewise found the variation higher in the males, but concluded that the apparent sex difference is of doubtful significance. The present data are in accordance with this conclusion.

Head

The coefficient of variation for the weight of the head in the Wistar strain is highest at birth (9.8) and lowest at 3 weeks (6.0). It is slightly higher at 12 weeks (6.9) than at 3 and higher at 1 year (7.8) than at 12 weeks. These same relations hold in the Long-Evans strain. Jackson ('13) found the coefficient of variation for the weight of the head to be highest at 3 weeks of age. The average coefficient of variation (four ages combined) for the weight of the head in the Wistar strain is 7.6, while it is 7.7 in the Long-Evans strain. Jackson found the average coefficient of variation for the weight of the head in albino rats to be 12. Thus the head is much less variable in weight in the rats used in this study than those studied by Jackson 20 years ago.

Integument

The coefficient of variation for the weight of the integument in the Wistar rats is lowest at 12 weeks (9.3) and highest at 1 year (13.1). It is higher at birth (11.0) than at 12 weeks and higher at 3 weeks (13.0) than at 12. These same relations hold in the Long-Evans strain. The average coefficient of variation (age groups combined) for the weight of the integument in the Wistar strain is 11.6 and in the Long-Evans strain is 12.7.

Skeleton

The coefficient of variation for the weight of the left humerus of the Wistar rats is highest at birth (11.7) and lowest at 12 weeks (6.6). It is higher at 3 weeks (7.6) than at 12 weeks and higher at 1 year (8.8) than at 3 weeks. In the Long-Evans strain the coefficient is highest at 1 year (11.6) and lowest at 12 weeks (8.0). The average coefficient of variation (age groups combined) for the weight of the left humerus is 8.7 in the Wistar strain and 9.6 in the Long-Evans strain.

The coefficient of variation for the weight of the left femur is highest in the Wistar strain at birth (16.9) and lowest at 12 weeks (8.4). It is higher at 1 year (10.3) than at 12 weeks and higher at 3 weeks (11.5) than at 1 year. This same relationship holds in the Long-Evans strain. The average coefficient of variation (age groups combined) for the weight of the left femur is 11.6 in the case of both strains.

There is, thus, a definite tendency in the case of both the humerus and femur for the coefficient of variation to be highest at birth and lowest at 12 weeks. The femur appears to be more variable than the humerus in every case.

Alimentary group

The coefficient of variation for the weight of the alimentary group of the Wistar rats is highest at birth (52.6) and lowest at 12 weeks (14.5). It is higher at 1 year (18.2) than at 12 weeks and higher at 3 weeks (19.3) than at 1 year. The coefficient is also highest in the Long-Evans strain at birth (37.2) and lowest at 12 weeks (15.6). It is highest in the newborn, since only a part of the rats had suckled. The average coefficient of variation (all ages combined) for the alimentary group in the Wistar strain is 26.2 and 23.1 in the Long-Evans strain. Jackson ('13) found an average coefficient of 35 for the weight of the intestinal canal (plus contents) in the albino rat.

Viscera

The coefficients of variation for the weight of each of the individual organs are given in tables 1 and 2. The average figures only will be discussed here. The average coefficient of variation for the viscera of the rats of the Wistar strain is highest at birth (18.3) and lowest at 12 weeks (12.8). It is only slightly higher at 3 weeks (13.1) than at 12 weeks, and it is higher at 1 year (17.3) than at 3 weeks. In the Long-Evans strain the average coefficient of variation for the viscera is highest at 1 year (19.9) and lowest at 12 weeks (14.4). It is somewhat higher at 3 weeks (15.4) than at 12 and slightly higher at birth (15.7) than at 3 weeks. The tendency, therefore, in both strains is for the coefficient of variation for the viscera to be highest at either birth or 1 year and for it to be lowest at 12 weeks. The average coefficient of variation (all ages combined) for the viscera is 15.4 in the Wistar strain and 16.3 in the Long-Evans strain.

Jackson ('13) found the average coefficient of variation for the viscera in the albino rat to be 25. He did not include a study of all the viscera reported here. Therefore, I computed the average coefficient of variation considering only those viscera which he reported. The results gave practically the same average as that found for the complete group. It is, therefore, evident that the viscera are much less variable in the rats included in this present study than those reported by Jackson ('13).

In the Wistar strain, the brain, spinal cord, and eyeballs form a group of low variability (average coefficient, 5 to 8). The suprarenal glands, stomach, intestines, submaxillary glands, liver, kidneys, heart, lungs, and ovaries form a group of moderate variability (average coefficient, 13 to 20). The hypophysis, thyroid, thymus, spleen, and uterus form the most variable group (average coefficient, 20 to 26). The organs of the Long-Evans animals fall in the same groups, with the exception of the ovaries which in this strain fall in the group of highest variability.

DISCUSSION

Jackson ('13), in his study of the albino rat, found variability in body weight as well as the average coefficient of variation for the viscera to be lowest at birth and highest at 3 weeks. As will be noted, there is a definite tendency for the coefficient of variation for body length, body weight, and the organ weights studied here to be highest at either birth or 1 year and to be lowest at either 3 or 12 weeks. It is difficult to say why Jackson found variability to be highest at 3 weeks and I found it to be lowest at that age. Jackson's rats grew very poorly from birth to 3 weeks. They averaged only 19.55 gm. in weight at 20 days, while my Wistar albino rats averaged 39.03 gm. at 3 weeks of age. The diet used by Jackson may not have supported lactation properly, resulting in some of the young getting enough food and others not being properly nourished. This would, of course, result in high variability at 3 weeks. Jackson's albino rats averaged 112.6 gm. in weight at 10 weeks, while mine averaged 171 gm. at this age. It is apparent that his animals grew quite poorly. This may be the cause of high variability at 3 weeks and at later ages. I discarded all rats at 3 weeks of age which did not weigh 35 gm. This probably is a factor tending to lower the variability at 3 weeks.

The coefficients of variation recorded here are much lower than those found by Jackson for albino rats in 1913. Undoubtedly, such factors as domestication, improved diet, uniformly good care, close breeding, etc., have been very important factors in bringing about this lowered variability. Variability in many cases is only about one-half that found by Jackson. These reduced coefficients of variation indicate clearly that a great advance has been made in the task of producing a standard rat for use in experimental work. Much credit for this is, of course, due to the constant efforts of The Wistar Institute of Anatomy and Biology, Philadelphia.

The fact that no consistent differences were found between the coefficients of variation of the two strains of rats used

is not surprising, since both have been maintained as pure strains under excellent conditions for many years.

SUMMARY

The coefficients of variation for body length, body weight, weight of head, integument, humerus, femur, alimentary group, and viscera have been computed for both the Wistar albino and the Long-Evans hybrid strain of the Norway rat. Animals were autopsied at birth and at (approximately) 3 weeks, 12 weeks, and 1 year of age. The average coefficient of variation (all ages and sexes combined) for each in the Wistar strain is as follows: body length, 3.6; body weight, 10; head, 7.6; integument, 11.6; humerus, 8.7; femur, 11.6; alimentary group, 26.2; and viscera, 15.4. Variability tends to be highest at either birth or 1 year and to be lowest at either 3 or 12 weeks.

Considering the individual viscera of the rats of the Wistar strain, the brain, spinal cord, and eyeballs form a group of low variability (average coefficient, 5 to 8). The suprarenal glands, stomach, intestines, submaxillary glands, liver, kidneys, heart, lungs, and ovaries form a group of moderate variability (average coefficient, 13 to 20). The hypophysis, thyroid, thymus, spleen, and uterus form the most variable group (average coefficient, 20 to 26).

There are no consistent differences in coefficients of variation between the two sexes or the two strains.

The coefficients of variation are found to be consistently much lower than those reported by Jackson ('13) for albino rats. This would seem to indicate that some success in standardizing the rat has been made.

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THE DEVELOPMENT OF THE SCAPULA FOLLOWING INTRA-UTERINE FORE LIMB AMPUTATION IN THE RAT

O. LARSELL

Anatomical Laboratories of the University of Oregon Medical School, and of the University of California

FOUR FIGURES

The problem of the effect of functional activity on the development of embryonic structure has been approached from various angles. The present report will describe the effects produced on the scapula of the laboratory rat by different degrees of muscular pull on this bone during the later part of foetal life. These variations of muscular activity were produced by intra-uterine amputations of one fore limb in a series of rat foetuses. The other fore limb, with its scapula, remained uninjured and served in each case as a control of the experiment.

The scapula lends itself admirably to a determination of any effect on its growth because of its flatness which makes possible measurements of axes and areas with relative ease. Its bony trabeculae also may be studied in serial sections and compared more readily than in other bones, so that it is possible to determine what effect, if any, has been produced on them by the stresses due to variations of muscular pull. Several of the important muscles of the scapula are attached to the forearm in such a manner that graded degrees of injury to the arm-scapular musculature may be inflicted. In some of the foetuses operated all of the forearm was destroyed, save the most proximal part of radius and ulna, to which the long head of the triceps brachii and the biceps are attached. This operation reduced the weight of the

movable parts which exert a pull on the scapula, but left intact all of the muscles attached to the scapula. More extensive injuries in other foetuses destroyed varying portions of the humerus, in addition to the forearm, with injury to the muscles also in varying degree. In only one case of destruction of the external limb was the scapula itself or its blood supply apparently involved in any way. In this instance (BH 6290-2) the cautery touched the shoulder itself, destroying the superficial muscles and apparently injuring the circumflex scapular artery and possibly the transverse scapular artery also. In this case the affected scapula was very much smaller at term than in the other experimental foetuses and was excluded from further consideration. In all the other foetuses only the fore limb and the muscles connecting this and the scapula were affected. By partial destruction of these muscles, or by varying the load upon them, varying stresses were placed upon the scapulae to which they were attached. Comparison of the two scapulae of operated individual animals, at birth or full term, show the results of the injury.

The animals and facilities for the operative work on which this report is based were provided by the anatomical laboratory of the University of California. It is a pleasure to extend my thanks to Dr. H. M. Evans and his staff for the facilities so freely placed at my disposal.

The animals used were of the Long-Evans strain of laboratory rats. The pregnant females were operated at 16 to 19 days' pregnancy by a lateral incision in much the same manner as described by Nicholas ('26). The cornu of the uterus was brought to the surface and a small incision was made opposite a fore limb of the foetus selected by means of an iridectomy scissors. Uterine wall and embryonic membranes were cut through and the amniotic fluid was allowed to escape. The foetus was then manipulated so that a fore limb protruded through the incision. The limb was then destroyed with an electrocautery. The uterine incision was allowed to close without suture and that portion of the uterus containing

the operated foetus was replaced into the abdominal cavity and another foetus was brought to the surface for operation. Usually 3 or 4 foetuses were operated in each rat and in one cornu only. In the operative procedure surgical asepsis was observed.

After operation the pregnant animals were placed into individual cages and allowed to come to term. It soon developed that deformed young were frequently eaten by the mothers shortly after birth. It therefore became necessary to watch closely for indications of parturition and to obtain the newborn young, which had been operated, immediately after delivery. In many cases, when it was apparent that delivery would take place late at night, the pregnant rats were killed as late as possible on the twenty-first day of gestation and the young were taken from the uterus. Some of the operated rats did not litter until the twenty-second day.

For the present experiment the young rats were fixed in Bouin's fluid or in Heidenhain's 'Susa,' and were subsequently preserved in alcohol until needed for study. The scapulae then were dissected out, stripped of their muscles and the pair from each young rat were drawn in outline with the aid of an Edinger-Leitz projection apparatus, at a magnification of 11.5 diameters. The remnant of the humerus on the operated side was included in the drawing in most instances. The axes of the scapulae were measured with dividers from the drawings, and the areas were likewise obtained from the drawings by means of a planimeter. The major axis or length of each scapula was readily obtainable from constant points (*a* to *b*, fig. 1, A) of the bones, but the points from which the breadth could be measured were so variable in position that no strictly comparable results could be obtained. The breadth measurements were discarded, therefore, and relative areas and lengths only were compared by computing the percentage of reduction of the affected scapula of each pair with respect to that of the unoperated side, which was considered normal unless there were marked indications to the contrary in each case. The results

of these computations are given in table 1, which for the sake of brevity includes only the percentage values for five typical pairs of scapulae and one pair (W2310-2) which is further described below. Dissections, drawings, and measurements were made of twenty pairs of scapulae and six pairs were cut in horizontal or transverse planes, serially, for study of the trabeculae. The sections were stained by the Mallory method or with azo-carmine.

The studies of Angulo y González ('32, p. 406) have shown that movements of the fore limbs first appear in the rat foetus on the sixteenth day of gestation. This stage had already been selected for the earlier operations before Angulo's ex-

TABLE 1

SPECIMEN	STAGE AT WHICH AMPUTATION WAS PERFORMED	APPROXIMATE REDUCTION IN SURFACE AREA OF AFFECTED SCAPULA	REDUCTION IN LENGTH OF AFFECTED SCAPULA
	Days	*Per cent*	*Per cent*
BH 9246	16	6.5	3.2
BH 6290-1	16	23	18.7
B 9114	16	34	19.3
BH 3213-2	18	14	12.1
BH 6949	19	12	11
W 2310-2	17	27	24.6

cellent paper appeared, but only on the grounds of somewhat casual observations of the intra-uterine movements of the foetus. Angulo's studies place the experimental work here reported on a firm foundation with reference to the onset of muscular activity of the parts involved. The experiments of Nicholas ('26) have shown that there is no regeneration of the injured embryonic limbs in rat foetuses.

The foetuses grow very rapidly from the sixteenth day to birth, and especially from the eighteenth day on. This is reflected in the growth of the scapula. In figure 1, G, the two scapulae of an 18-day foetus are shown in outline, drawn to the same scale as figure 1, A–F, which are from newborn young or full term foetuses which were operated at 16 to 19 days. At 18 days and earlier the scapular muscles are func-

tional but movements of the fore limb are spasmodic and irregular. From 18 days and on, however, there is greater independence of secondary movements and individuation of limb action (Angulo, '32, p. 418).

The results of destruction of the fore limb in greater or less degree are shown in figure 1, A–F. The scapulae shown in

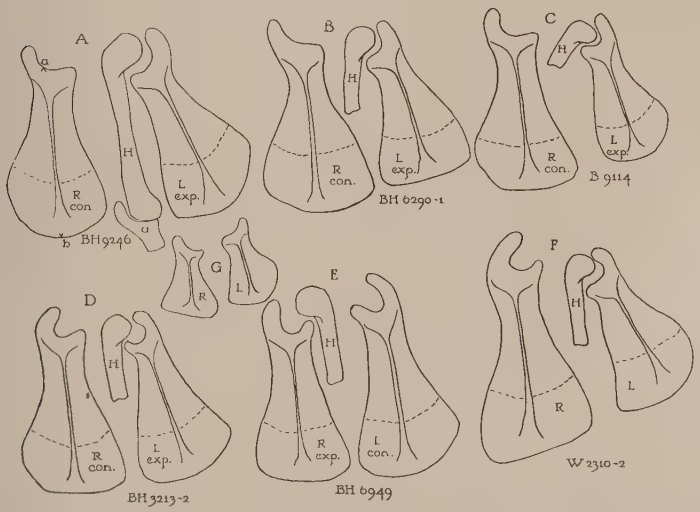

Fig. 1 Outline drawings of pairs of scapulae and the remaining bones of the operated fore limb from newborn rats or full term foetuses. All drawings made with aid of Edinger-Leitz projection apparatus. Reduced to × ca. 4.5. *A*, Scapulae, left humerus and part of ulna of newborn rat in which the forearm was almost completely destroyed at 16 days. *B*, Scapulae and part of left humerus of newborn rat in which the destruction of the left fore limb extended about halfway above the elbow. Operated at 16 days. *C*, Scapulae and proximal part of left humerus of full term foetus in which destruction of left fore limb was nearly complete. Operated at 16 days. *D*, Scapulae and part of left humerus of full term foetus operated at 18 days, in which destruction of fore limb was approximately equal to that shown by figure 1, B. *E*, Scapulae and part of right humerus of full term foetus operated at 19 days, in which destruction of fore limb was about equal to that shown in 1, B and 1, D. *F*, Scapulae and part of left humerus of full term foetus operated at 17 days. The right fore limb projected through the uterine wall at term. The left fore limb had been destroyed to a level about halfway between elbow and shoulder. *G*, Normal scapulae of foetus at 18 days, drawn to same scale, *a–b*, points of measurement of longitudinal axis; *con.*, control scapula; *exp.*, experimental scapula; *H*, humerus; *L*, left scapula; *R*, right scapula; *U*, ulna.

figure 1, A (foetus BH 9246), are from a foetus in which most of the forearm had been destroyed on the left side, leaving only part of the ulna and its immediately adjacent structures. The humerus itself and the muscles connecting humerus and scapula were uninjured. There is a slight reduction both in area and length of the left scapula as compared with the unaffected right scapula, as indicated in table 1, namely, 6.5 per cent smaller area and 3.2 per cent shorter. It appears plausible that the lessened weight of the left fore limb reduced the work performed by the muscles connecting scapula and fore limb sufficiently to account for the slight atrophy observed in the development of the left scapula.

In figure 1, B (BH 6290-1), a more marked difference between the two scapulae is observed. In this case the fore limb was destroyed to the extent that about half of the humerus was included. There was thus greater reduction in the weight pulled by the scapular muscles and several of the more important of these muscles, namely, the biceps and long head of the triceps brachii, the coracobrachialis, and in large part, if not completely, the deltoid attachments to the bones of the forelimb were destroyed, together with the distal parts of these muscles themselves. It will be noted from the table that the affected scapula, the right in this case, is considerably smaller and shorter than the corresponding bone on the unoperated side.

The outlines of a pair of scapluae are shown in figure 1, C (B 9114), from a newborn rat in which the entire fore limb had been destroyed, leaving only the head of the humerus and a small portion of the adjacent shaft. The muscles were not dissected away individually, so that it cannot be stated with certainty which of them remained attached to the humerus, but from the remnant of the bone which was found it appears likely that the supraspinatus and the infraspinatus were the principal muscles which had any intact insertion on the humerus. As shown in the table, the right scapula is smaller by 29 per cent in area and is 23.4 per cent shorter than the unaffected left scapula from the same animal.

The three typical cases illustrated are taken from a larger number of full term or newly born rats which had been operated on the sixteenth day of gestation. All show a failure of scapular development which is approximately proportional to the amount of forearm destroyed, and apparently in proportion to the degree of lessened muscular pull on the shoulder blade. As a check on this interpretation the scapulae of full term and newborn rats which had been operated at 17, 18 and 19 days of development were compared with those operated at the earlier stage. Specimens were selected in which the amount of injury inflicted was approximately the same, as indicated by the remaining stump of the humerus. Comparison of figure 1, D (BH 3213-2, operated at 18 days) and figure 1, E (BH 6949, operated at 19 days), with figure 1, B (BH 6290-1, operated at 16 days), shows a much smaller scapula, actually and relatively, in the case of the animal operated at the earlier stage; and the percentages of area and length reduction given in table 1 show a progressively lessened amount in foetuses operated at the later stages, when the amount of injury inflicted is comparable.

Thus the development of the scapula of the operated side, as compared with the intact side of the foetus, appears to bear a direct relation to the amount of destruction inflicted at operation, and to the stage of gestation at which the limb was injured. The greater the destruction of the parts of the fore limb to which the scapular muscles are inserted the smaller is the scapula at term, as compared with its mate. With reference to the gestation stage, the earlier the injury is inflicted, in the development of the foetus, the smaller is the scapula whose muscles were affected, as compared with the other side, at term. Both of these conclusions point to a direct effect of the action of the muscles connecting arm and scapula on the development of the latter.

An interesting check on the above conclusion is afforded by the full term foetus illustrated in figure 2. The mother rat in this case was killed in the late evening of the twenty-first day of gestation for reasons stated above. In addition to

several other operated foetuses with fore limbs destroyed in greater or less degree, which were present in the usual positions in the uterus, the foetus illustrated was found with the right fore limb projecting through the uterine wall into the abdominal cavity of the mother. The arm was swollen beyond normal size, but otherwise appeared normal externally. The uterine wall was constricted about the arm approximately midway between the elbow and the head of the humerus in such a manner that the limb was firmly caught in place. The portion of the cornu containing this foetus was removed with the foetus in position and was placed into Bouin's fluid and later into alcohol. The photograph reproduced in figure 2

Fig. 2 Photograph of full term rat foetus in utero with right fore limb projecting through incision made in uterine wall at 17 days, when left fore limb was amputated. The foetus was well developed and active at term.

was taken and the uterus dissected away. The other (left) fore limb had been cauterized. Subsequent dissection showed that about half of the humerus remained on the left side (fig. 1, F). In some manner the intact fore limb had protruded through the opening in the uterine wall subsequent to operation and had become caught in this position. It is not possible to state when this took place, but it must have been quite early after operation, since, in all other cases observed, the uterine wall, which frequently was enlarged inadvertently by the cautery, was completely closed with only a small scar to mark the position of the incision.

In the present case the additional load placed upon the muscles of the shoulder girdle on the right side, as they pulled against the uterine wall, must have been considerable. The

right scapula of this rat (fig. 1, F, W 2310-2) is proportionately much larger than in any of the other operated rats, save B 9114, in which nearly the entire fore limb had been destroyed at 16 days. The right scapula of W 2310-2 must be regarded as showing an hypertrophy caused by more than normal pull of the muscles attached to it, while the left scapula has undergone an atrophy due to less than the normal activity of its muscles. It will be noted from the figures that the right

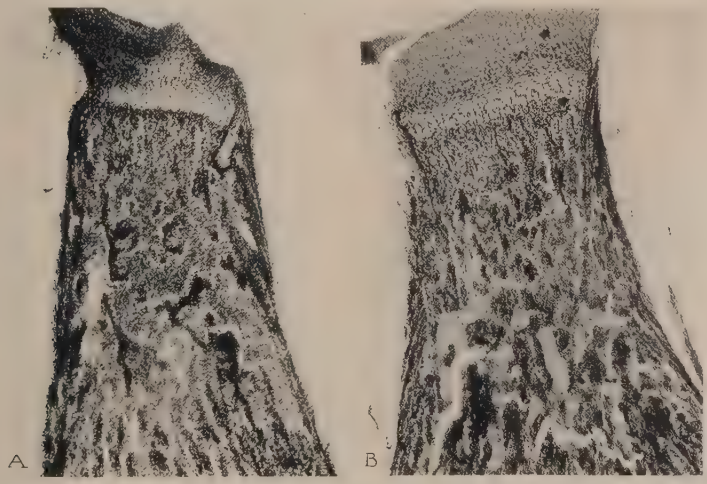

Fig. 3 *A*, Photomicrograph of portion of a section through the affected scapula of full term rat foetus (B 2310-2) in which the left fore limb was amputated at 17 days. Horizontal series. 20 μ. Mallory stain.

Fig. 3 *B*, Photomicrograph of portion of right (normal) scapula of same animal taken at same magnification. Horizontal series. 20 μ. Mallory stain.

scapula in this case is but slightly larger than some of the normal scapulae of other experimental rats, but such comparison may be misleading because of the variation in size of different individual animals at birth. The only proper comparison must be with the opposite scapula of the same animal. On the basis of such comparison the disparity both in length and area of the two shoulder blades from W 2310-2 is greater than in any other of the twenty pairs measured, save B 9114 (fig. 1, C), as noted.

Sections cut through the length of the scapula, in the horizontal plane, show differences in the cartilaginous zones of growth and in the number and arrangement of the bony trabeculae, especially at the neck of the scapula, as the most striking effects of the experimental procedure. In the normal control scapula shown in figure 3, B, the cartilaginous zone of growth is broad, with large cartilage cells shown in

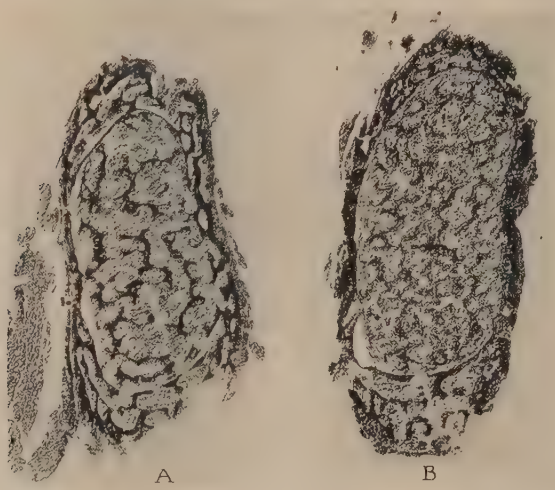

Fig. 4 *A*, Photomicrograph of section through neck of left scapula of full term rat foetus (BH 6290-2) in which the left fore limb was amputated at 16 days. Section 10 μ. Azo-carmine stain.

Fig. 4 *B*, Photomicrograph of section through corresponding level of right (normal) scapula of same full term foetus, taken at same magnification. Section 10 μ. Mallory stain.

typical columnar arrangement. The affected scapula of the same animal shows, in addition to the smaller size of the entire bone already described, a narrow zone of cartilage cells and much less apparent activity in growth (fig. 3, A).

The bony trabeculae are present, in the neck of the scapula, as numerous narrow spicules of bone set close together, with vascular spaces and bone marrow between. In the normal scapula the spicules are numerous and small and the marrow

spaces are relatively narrow. These features are better shown in a transverse section through the neck of the scapula (fig. 4, B). On the operated side the trabeculae are few and relatively coarse, apparently representing trabeculae formed early in the development of the bone which have not been modified to the same degree as on the normal side during subsequent growth. The marrow spaces are also larger on the operated side (figs. 3, A and 4, A). It will be noted that the area of the entire cross section of the affected scapula, which was selected as carefully as possible to correspond to that of the normal side, as respects its relative position, is considerably less than the normal section.

DISCUSSION

It does not seem possible to explain the effects consistently produced on the development of the affected scapulae on the grounds of injury to the scapular blood vessels. The nearest large blood vessel, with reference to the scapula, which could have been affected in the amputations is the distal part of the proximal portion of the brachial artery. It does not appear possible that the subscapular branch of this artery could have been injured in any save one of the foetuses. Furthermore, if the rat foetus has as rich a blood supply to the scapula from anastomosing arteries of several origins as have other adult mammals, it does not appear likely that any possible injury to the external limb which did not also involve the shoulder itself could affect the blood supply to this bone. This statement is substantiated by one full term foetus in which the shoulder itself had been injured by the cautery. The scapula beneath showed very great atrophy as compared with the normal, due in part, apparently, to destruction of blood vessels which are so placed as to have been involved.

Toxic products from the cauterized tissues would return through the lymphatics of the arm and shoulder to the general circulation and would probably affect other parts of the body about equally with the experimental scapula. Their effect is therefore discarded as a factor.

It appears to the writer that the explanation of the effects above described must be associated with lines and planes of stress produced in the developing bone by the activity of the muscles attached to it. Such lines and planes of stress must set up zones of increased metabolic activity about themselves, one result of which is increased growth through greater proliferation of the cartilage cells in the zones of cartilage formation. In some similar manner the sculpturing action of osteoclasts is also increased, together with increased activity of the osteoblasts, as is shown by the rearrangement and increased number of trabeculae in the normal bone, as compared with the experimental side.

LITERATURE CITED

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Nicholas, J. S. 1926 Extirpation experiments upon embryonic forelimb of rat. Proc. Soc. Exp. Biol. and Med., vol. 23, pp. 436–439.

PROCEEDINGS OF THE AMERICAN ASSOCIATION OF ANATOMISTS

FORTY-NINTH SESSION

College of Medicine, University of Cincinnati, Cincinnati, Ohio, April 13, 14, and 15, 1933

Thursday, April 13, 1933

9.45 a.m. The Forty-ninth Session of the American Association of Anatomists was called to order by President George E. Coghill, who announced the appointment of the following committees:

Auditing Committee: Professor Andrew T. Rasmussen, Chairman; Professor Ira D. Hogg.

Nominating Committee for 1934: Professor G. Carl Huber, Chairman; Professor Ross G. Harrison, Professor Olof Larsell.

The remainder of the session was devoted to the presentation of scientific papers.

Friday, April 14, 1933

12 noon. Business Meeting, President George E. Coghill in the chair. The Secretary reported that the minutes of the Forty-eighth Session were printed in The Anatomical Record, volume 52, no. 3, pp. 265–271, inclusive. On motion, seconded and carried, the minutes were approved as printed.

Report of the Treasurer: The Treasurer made the following report for the year 1932:

Balance on hand December 31, 1931 (last audit of accounts)	$993.60	
Receipts from dues	466.98	
Interest on deposits	32.40	
Total credits		$1492.98
Expenditures, 1932:		
Stamps, postage	49.05	
Stationery	10.78	
Printing, addressing	43.71	
Programs, 48th meeting	90.00	
Secretarial assistance	1.50	
Traveling expenses, secretary	46.60	
Express	.65	
Bank charges	.12	
Local committee, 48th meeting	150.00	
Stereopticon, 48th meeting	15.00	
Tax on checks	.02	
Total expenditure		407.43
Balance on hand December 28, 1932, and deposited in the name of the American Assocation of Anatomists in the Lincoln-Alliance Bank and Trust Company, Rochester, New York		$1085.55

Report of the Auditing Committee: Professor A. T. Rasmussen reported as follows:

"The undersigned Auditing Committee has examined the accounts of the Secretary-Treasurer for the year 1932, and finds total receipts to be those entered in the journal, expenditures in accordance with receipted bills, and the balance on hand December 28, 1932, in agreement with the bank statement of that date."

[Signed] A. T. Rasmussen,
I. D. Hogg.

On motion, duly seconded, the reports of the Treasurer and of the Auditing Committee were accepted and adopted.

Election of Members of the Executive Committee: Professor Richard E. Scammon, Chairman of the Committee on Nominations for 1933, placed before the Association the following nominations:

For members of the Executive Committee, Professor John L. Bremer, of Harvard Medical School, and Professor Harold D. Senior, of New York University and Bellevue Hospital Medical College.

On motion, seconded and carried, the Secretary was instructed to cast a ballot for the election of the above-named, with terms of office as specified in the Constitution of the Association.

New members: The Secretary presented the following names recommended by the Executive Committee for election to membership in the Association:

Barron, Donald H., B.A., M.S., Ph.D., Instructor in Anatomy, Albany Medical *College, Albany, N. Y.*

Chandler, Simon B., A.B., A.M., M.D., Associate Professor of Anatomy, Loyola University School of Medicine, *706 S. Lincoln St., Chicago, Ill.*

Collings, M. Raymond, M.D., Associate Professor of Anatomy, Detroit College *of Medicine and Surgery, Detroit, Mich.*

DuBois, Franklin S., A.B., M.S., M.D., Assistant Professor and Acting Head, *Department of Anatomy, University of Alabama, University, Ala.*

Gersch, Isidor, B.S., Ph.D., Fellow of the Rockefeller Foundation, *Department of Anatomy, University of Chicago, Chicago, Ill.*

Grant, Madeleine P., S.B., M.A., Ph.D., Assistant Professor of Zoölogy, *Smith College, Northampton, Mass.*

Guthrie, Mary J., A.B., A.M., Ph.D., Associate Professor of Zoölogy, *University of Missouri, Columbia, Mo.*

Hall, Edmund K., D.Sc., Ph.D., Instructor in Anatomy, *University of Louisville Medical School, Louisville, Ky.*

Haterius, Hans Oliver, A.B., M.S., Ph.D., Assistant Professor of Biology, *Washington Square College, New York University, New York City.*

Hisaw, Frederick L., A.B., A.M., Ph.D., Professor of Zoölogy, *University of Wisconsin, Madison, Wis.*

Hoerr, Normand L., B.A., Ph.D., M.D., Instructor in Anatomy, *University of Chicago, Chicago, Ill.*

Hollinshead, William H., A.B., M.S., Ph.D., Instructor in Anatomy, *Duke University Medical School, Durham, N. C.*

Lucas, Alfred M., Ph.D., Assistant Professor of Cytology, *Washington University Medical School, St. Louis, Mo.*

Lyons, William R., Ph.D., Instructor in Anatomy, *University of California, Berkeley, Calif.*

Maclean, Bernice L., A.B., Ph.D., Research Assistant in Ophthalmology, Columbia University, *630 W. 168th St., New York City.*

Meyer, Roland K., A.B., Ph.D., Fellow in Anatomy, *University of Rochester, Crittenden Boulevard, Rochester, N. Y.*

Miller, Ruth Alexandria, A.B., Ph.D., Instructor in Anatomy, College of Physicians and Surgeons, Columbia University, *630 W. 168th St., New York City.*

Nelson, Warren O., A.B., Ph.D., National Research Council Fellow, Department of Zoölogy, *University of Chicago, Chicago, Ill.*

Pankratz, David S., A.B., A.M., Ph.D., Assistant Professor of Anatomy, *University of Tennessee, Memphis, Tenn.*

Parker, Raymond C., B.A., Ph.D., Associate of the Rockefeller Institute, *66th St. and York Ave., New York City.*

Robertson, W. R. B., A.B., M.S., Ph.D., Associate in Anatomy, *University of Iowa, Iowa City, Ia.*

Ruth, Elbert B., A.B., Ph.D., Instructor in Anatomy, *University of Rochester, Crittenden Boulevard, Rochester, N. Y.*

Schour, Isaac, B.S., D.D.S., M.S., Ph.D., Associate Professor of Histology, University of Illinois College of Dentistry, *1338 W. Harrison St., Chicago, Ill.*

Seib, George A., A.B., M.D., Instructor in Anatomy, *Washington University, 2323 Lafayette Ave., St. Louis, Mo.*

Singer, Edward, M.D., Associate in Anatomy, College of Physicians and Surgeons, Columbia University, *630 W. 168th St., New York City.*

Spector, Benjamin, M.D., Professor of Anatomy, *Tufts Medical College, 416 Huntington Ave., Boston, Mass.*

Tharaldsen, Conrad E., B.S., M.A., Ph.D., Professor of Anatomy, *New York Homeopathic Medical College, York Ave. and 64th St., New York City.*

Turner, Charles W., B.S., A.M., Ph.D., Associate Professor of Dairy Husbandry, *University of Missouri, Columbia, Mo.*

Van Cleave, C. D., A.B., Ph.D., Instructor in Anatomy, *University of Pennsylvania Medical School, Philadelphia, Pa.*

Vonderahe, A. R., A.B., B.Sc., M.D., Assistant Professor of Anatomy, *University of Cincinnati, College of Medicine, Eden Ave., Cincinnati, Ohio.*

On motion, duly seconded, the Secretary was instructed to cast a ballot for all candidates proposed by the Executive Committee.

Members Deceased: The Secretary then announced that the Association has suffered great loss in the death of the following active members:

George Fetterolf, Philadelphia, Pa.
Howard Hill, Kansas City, Mo.
Ernst Huber, Baltimore, Md.
Thomas G. Lee, Babson Park, Fla.
Joseph Leidy, Jr., Philadelphia, Pa.
William Patten, Hanover, N. H.
Herman v. W. Schulte, Omaha, Neb.
Frederick W. Thyng, Boston, Mass.

Resignation of Members: The Secretary then announced, on behalf of the Executive Committee, the resignation of the following members:

Laura Florence, New York City.
Nils Holmgren, Stockholm, Sweden.
Stewart Paton, Baltimore, Md.
Ernest Sachs, St. Louis, Mo.
Alan C. Sutton, Colorado Springs, Colo.

Members Dropped: The Secretary then announced the following names dropped from the list of members on account of non-payment of dues for the past two years:

A. J. Schneider, Washington, D. C.
C. Sharp, Brooklyn, N. Y.
Y. Shimidzu, Nagasaki, Japan.

Honorary Members: It was reported, on behalf of the Executive Committee, that earnest consideration had been given to the question of electing distinguished foreign anatomists to honorary membership in the Association, which question was submitted to it at the Forty-eighth Session as a special order of business for this year. The Executive Committee recommended that action be deferred for one year, pending further study of the question. On motion, it was voted to adopt the recommendation.

Election of Representatives: The Secretary then read, on behalf of the Executive Committee, the following nominations: Representative on the Commission for the Standardization of Biological Stains, Professor H. E. Jordan; Representatives on the Council of the American Association for the Advancement of Science, Professors George W. Bartelmez and George B. Wislocki.

The persons proposed were elected.

Representative to the Division of Medical Sciences of the National Research Council: The Secretary announced, on behalf of the Executive Committee, the receipt of a letter from Dr. Stanhope Bayne-Jones, Chairman of the Medical Division of the National Research Council, relating to new articles of organization of the Council, and inviting the Association to nominate one of its members to serve as an executive member of the Division of Medical Sciences. The Executive Committee having considered this invitation, recommended that the Association accept it, and further advised

that the transition from the former to the new form of representation could be effected without any change in the Constitution or Orders of the Association by electing a representative at once to serve for one year, another election for the full term of three years to take place in 1934. On motion, duly seconded, it was voted to accept the invitation.

The Executive Committee then recommended the election of Professor Lewis H. Weed as Executive Member of the Division of Medical Sciences of the National Research Council, from July 1, 1933 to July 1, 1934.

On motion, duly seconded, Doctor Weed was elected.

Payment to Local Committee: In accordance with the policy adopted by the Association at the Forty-third Session, it was moved, seconded, and voted that the Treasurer be authorized to make a payment not exceeding $150.00, from the general funds of the Association, to the Local Committee on Arrangements at the College of Medicine, University of Cincinnati, for the purpose of defraying the cost of entertainment of the Association during the present Forty-ninth Session.

Dues for the year 1933: A recommendation of the Executive Committee, that the dues for the year 1933 be set at one dollar per member, was adopted by the Association.

Place of Next Meeting: It was announced that the Executive Committee had decided to hold the fiftieth session of the Association at the University of Pennsylvania, Philadelphia, on the three days immediately preceding Easter, 1934 (March 29, 30, 31).

New Business: The Secretary read a statement from the Chairman of the Committee on Cost of Current Periodicals, of the Medical Library Association, dealing with the present exorbitant costs of German scientific periodicals. On motion, a resolution was passed expressing the deep concern of the Association regarding this situation, which the Secretary was directed to make known in the proper quarters after consulting with the above-named Committee of the Medical Library Association.

The Secretary then stated that the Executive Committee had discussed various proposals to relieve the present overcrowding of the scientific program and the consequent shortening of time for reading papers. Suggestions from the members were invited.

On motion, the Business Session then adjourned.

SATURDAY, APRIL 15, 1933

12 noon. A short business session followed the morning scientific sessions. The Secretary reported that there was no unfinished business.

Resolution of Appreciation: Professor B. C. H. Harvey presented the following resolution:

The members of the American Association of Anatomists, meeting as guests of the College of Medicine of the University of Cincinnati, express their appreciation of the privilege of meeting in the beautiful halls and laboratories placed so freely at their disposal. The members are grateful also for the welcome given them by the city and for the opportunity they have enjoyed of becoming somewhat acquainted with its distinctive character and culture. And especially the Association wishes to thank Professor Malone and the members of his department, the Dean of the College, and the President of the University for the thoughtful and kindly hospitality which has distinguished the session.

The resolution was moved, seconded, and unanimously adopted. The Secretary was then directed to send copies of the resolution to the persons named in it and to the City Manager and the Cincinnati Chamber of Commerce, and also to transmit the thanks of the Association to the Hotel Gibson for its exceptional service and hospitality.

Resolution of Greetings: The following resolution was then moved, seconded, unanimously adopted, and ordered sent by telegram to Professor Henry McE. Knower:

The American Association of Anatomists, meeting in the laboratories which you planned, deeply regrets your absence and sends you greetings and best wishes.

On motion, the Session adjourned.

GEORGE W. CORNER,
Secretary of the Forty-ninth Session of the American Association of Anatomists.

Addendum to the Minutes: Professor Wislocki having indicated his inability to serve as delegate to the Association for the Advancement of Science, the Executive Committee subsequently appointed Professor J. L. Bremer.

AMERICAN ASSOCIATION OF ANATOMISTS

OFFICERS AND LIST OF MEMBERS

Officers

President.....George E. Coghill
First Vice-President.....Benjamin F. Kingsbury
Second Vice-President.....George W. Bartelmez
Secretary-Treasurer.....George W. Corner

Executive Committee

For term expiring 1934.....Leslie B. Arey, Samuel R. Detwiler
For term expiring 1935.....Paul I. McKibben, Edward F. Malone
For term expiring 1936.....Robert S. Cunningham, Augustus G. Pohlman
For term expiring 1937.....John Lewis Bremer, Harold D. Senior

Delegates to the Council of A.A.A.S. for 1933

George W. Bartelmez
John Lewis Bremer

Representative to the National Research Council, 1933–1934

Lewis H. Weed

Member of the Commission on Standardization of Biological Stains

Harvey E. Jordan

Delegate to Union of Biological Societies, 1932–1935

Henry H. Donaldson

Committee on Nominations for 1934

G. Carl Huber, *Chairman*
Ross G. Harrison Olof Larsell

Honorary Members

S. Ramón y Cajal.....*Madrid, Spain*
A. Nicolas.....*Paris, France*

ABBOTT, MAUDE E., B.A., C.M., M.D., L.R.C.P. & S. (Edin.), F.R.C.P. (Canada), Assistant Professor of Research Medicine and Curator of Medical Historical Museum, McGill University, *3640 University St., Montreal, Canada.*

ABERLE (MRS.), SOPHIE B. D., A.B., A.M., Ph.D., M.D., Instructor Obstetrics and Gynecology, *Yale University, School of Medicine, New Haven, Conn.*

ADAMS, A. ELIZABETH, A.B., A.M., Ph.D., Professor of Zoölogy, *Mount Holyoke College, South Hadley, Mass.*

ADAMS, L. A., A.B., A.M., Ph.D., Assistant Professor of Zoölogy, *University of Illinois, 406 Nevada St., Urbana, Ill.*

ADDISON, WILLIAM HENRY FITZGERALD, B.A., M.D., Professor of Normal Histology and Embryology, *School of Medicine, University of Pennsylvania, Philadelphia, Penna.*

ADELMANN, HOWARD B., B.A., M.A., Ph.D., Assistant Professor of Histology and Embryology, *Cornell University, Stimson Hall, Ithaca, N. Y.*

ALLEN, BENNET MILLS, Ph.D., Professor of Zoölogy, University of California (Southern Branch), *909 Micheltorena St., Los Angeles, Calif.*

ALLEN, EDGAR, A.M., Ph.D. (Vice-Pres. '30–'32), Professor of Anatomy and Dean of the School of Medicine, *University of Missouri, Columbia, Mo.*

ALLEN, EZRA, A.M., Ph.D., Associate Editor, Biological Abstracts; Associate Professor of Histology and Embryology, *New York Homeopathic Medical School, York Ave. and Sixty-fourth St., New York City.*

ALLEN, WILLARD M., A.B., M.A., M.D., *University of Rochester, School of Medicine and Dentistry, Rochester, N. Y.*

ALLEN, WILLIAM F., A.M., Ph.D., Head of Department of Anatomy, *University of Oregon Medical School, Portland, Ore.*

ALLIS, EDWARD PHELPS, JR., C.E., M.D., LL.D., *Palais de Carnoles, Menton (A.M.), France.*

ANDERSEN, DOROTHY H., M.D., Instructor in Pathology, *Columbia University, 630 West 168th Street, New York City.*

ANGULO Y GONZÁLEZ, ARMANDO W., A.B., B.S., A.M., Ph.D., Associate Member, *The Wistar Institute of Anatomy, 36th Street and Woodland Ave., Philadelphia, Pa.*

ANSON, BARRY J., A.B., A.M., Ph.D., Associate Professor of Anatomy, *Northwestern University Medical School, 303 East Chicago Ave., Chicago, Ill.*

APPLEBY, J. I., A.B., M.B., A.M., M.D., Physician and Surgeon, Company Surgeon, N. Y. C. & St. L. R. R. Co., *105½ East Main St., Bellevue, Ohio.*

AREY, LESLIE B., Ph.D. (Ex. Com. '30–), Robert Laughlin Rea Professor of Anatomy, and Chairman of the Division of Anatomy, *Northwestern University Medical School, 303 East Chicago Ave., Chicago, Ill.*

ARMSTRONG, PHILIP BROWNELL, B.S., M.D., Assistant Professor of Anatomy, *Cornell University Medical College, 1300 York Ave., New York City.*

ASDELL, SYDNEY ARTHUR, Ph.D., Assistant Professor in Charge of Physiology of Reproduction, State College of Agriculture, *Cornell University, Ithaca, N. Y.*

ATTERBURY, RUTH RAND, A.M., Ph.D., *144 Overlook Ave., Great Neck, L. I.*

ATWELL, WAYNE JASON, A.M., Ph.D., Professor of Anatomy, University of Buffalo School of Medicine, *24 High St., Buffalo, N. Y.*

BADERTSCHER, JACOB A., Ph.D., Professor of Anatomy, Indiana University School of Medicine, *312 South Fess Ave., Bloomington, Ind.*

BAGLEY, CHARLES, JR., M.D., Assoc. Experimental Neurology, *The Latrobe Apts., Baltimore, Md.*

BAILEY, PERCIVAL, M.D., Ph.D., Professor of Surgery, *University of Chicago, 950 East Fifty-ninth St., Chicago, Ill.*

BAITSELL, GEORGE ALFRED, B.S., M.A., Ph.D., Professor of Biology, Yale University, *Osborn Zoölogical Laboratory, New Haven, Conn.*

BAKER, R. C., A.B., M.A., Ph.D., Professor of Anatomy, *Department of Anatomy, Hamilton Hall, Ohio State University, Columbus, Ohio.*

BALDWIN, WESLEY MANNING, A.B., A.M., M.D., Professor of Anatomy, *Albany Medical College, Albany, N. Y.*

BARDEEN, CHARLES RUSSELL, A.B., M.D. (Ex. Com. '06–'09, Vice-President '18–'20), Professor of Anatomy and Dean of Medical School, *University of Wisconsin, Science Hall, Madison, Wis.*

BARRON, DONALD H., B.A., M.S., Ph.D., Instructor in Anatomy, Albany Medical *College, Albany, N. Y.*

BARTA, EDMUND, M.D., Adjunct, Department of Anatomy, Histology and Embryology, *Royal University Medical School, IX.Tuzotto-u. 58, Budapest, Hungary.*

BARTELMEZ, GEORGE W., Ph.D., Professor of Anatomy, *University of Chicago, Chicago, Ill.*

BARTSCH, PAUL, B.S., M.S., Ph.D., Curator of Mollusks and Cenozoic Invertebrates, *U. S. National Museum, Washington, D. C.*

BASCOM, KELLOGG F., B.A., M.S., Ph.D., M.D., Assistant in Surgery, *Northwest Clinic, Minot, N. D.*

BAST, T. H., B.A., Ph.D., Associate Professor of Anatomy, *University of Wisconsin, 308 Science Hall, Madison, Wis.*

BATSON, O. V., A.M., M.D., Professor of Anatomy, *Department of Anatomy, Graduate School of Medicine, University of Pennsylvania, Philadelphia. Pa.*

BAUMGARTNER, WILLIAM J., A.B., A.M., Ph.D., Professor of Zoölogy, University of Kansas, *1209 Ohio St., Lawrence, Kans.*

BEAN, ROBERT BENNETT, B.S., M.D., Professor of Anatomy, University of Virginia, *5 Wayside Place, University, Va.*

BEATTIE, JOHN, M.D., D.Sc., Associate Professor of Anatomy, *McGill University, Montreal, Canada.*

BEGG, ALEXANDER S., B.S., M.D., Waterhouse Professor of Anatomy and Dean, Boston University School of Medicine, *80 East Concord St., Boston, Mass.*

BENSLEY, ROBERT RUSSELL, A.B., M.B., Sc.D. (Second Vice-Pres. '06–'07, Ex. Com. '08–'12, President '18–'20), Professor of Anatomy, Director of Hull Laboratory of Anatomy, *University of Chicago, Chicago, Ill.*

BEST, R. RUSSELL, B.Sc., M.D., Assistant Professor of Anatomy, Instructor in Surgery, Department of Anatomy, University of Nebraska, College of Medicine, *1520 Medical Arts Building, Omaha, Neb.*

BEVAN, ARTHUR DEAN, M.D. (Ex. Com. '96–'98), Professor of Surgery, University of Chicago, *122 South Michigan Blvd., Chicago, Ill.*

BIGELOW, ROBERT P., S.B., Ph.D., Professor of Zoölogy and Parasitology, *Massachusetts Institute of Technology, Cambridge A, Mass.*

BISHOP, KATHERINE SCOTT, A.B., M.D., *1508 La Loma Ave., Berkeley, Calif.*

BLACK, DAVIDSON, M.A., M.D., Professor of Anatomy, Peking Union Medical College, and Hon. Director, Cenozoic Laboratory, Geological Survey of China, *P. U. M. C., Peiping, China.*

BLAIR, VILRAY PAPIN, A.M., M.D., Professor of Clinical Surgery, Washington University School of Medicine, *Metropolitan Building, St. Louis, Mo.*

BLAISDELL, FRANK ELLSWORTH, SR., M.D., Emeritus Professor of Surgery, Medical Department of Stanford University, *Lane Medical Library Building, corner Webster and Sacramento Sts., San Francisco, Calif.*

BLAKE, J. A., A.B., Ph.B., M.A., M.D., F.A.C.S., *Agua Caliente Ranch, Tucson, Arizona.*

BLINCOE, HOMER, A.B., M.S., M.D., Professor of Gross Anatomy, *Emory University, Emory, Georgia.*

BLOOM, WILLIAM, A.B., M.D., Assistant Professor of Anatomy, *Department of Anatomy, University of Chicago, Chicago, Ill.*

BLOUNT, R. F., Ph.D., Instructor in Anatomy, *University of Minnesota, Minneapolis, Minn.*

VON BONIN, GERHARDT, M.D., Associate in Anatomy, University of Illinois, College of Medicine, *1853 West Polk St., Chicago, Ill.*

BOYD, EDITH, M.D., Assistant Professor, *Institute of Child Welfare, University of Minnesota, Minneapolis, Minn.*

BOYDEN, EDWARD ALLEN, A.M., Ph.D. (Ex. Com. '28–'32), Professor of Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

BREMER, JOHN LEWIS, A.B., M.D., (Ex. Com. '15–'18, '33–), Hersey Professor of Anatomy, *Harvard Medical School, Boston, Mass.*

BROWNING, WILLIAM, Ph.B., M.D., Emeritus Professor of Neurology, Long Island College of Medicine, *54 Lefferts Place, Brooklyn, N. Y.*

BRYCE, THOMAS H., M.A., M.D., F.R.S., Professor of Anatomy, University of Glasgow, *No. 2, The University, Glasgow, Scotland.*

BULLARD, H. HAYS, A.M., Ph.D., M.D., *St. Vincent's Hospital, Erie, Pa.*

BUNTING, CHARLES HENRY, B.S., M.D., Professor of Pathology, *University of Wisconsin, Service Memorial Institute, Madison, Wis.*

BURNS, B. I., A.B., A.M., M.D., Professor of Anatomy, *Louisiana State University Medical Center, New Orleans, La.*

BURNS, ROBERT K., JR., A.B., Ph.D., Associate Professor of Anatomy, *University of Rochester School of Medicine and Dentistry, Rochester, N. Y.*

BURR, HAROLD SAXTON, Ph.D. (Ex. Com. '29–'33), Professor of Anatomy, School of Medicine, Yale University, *333 Cedar St., New Haven, Conn.*

BURROWS, MONTROSE T., A.B., M.D., Physician and Surgeon, Consultant Pathologist Los Angeles County General Hospital, *94 N. Madison Ave., Pasadena, Calif.*

BUTCHER, EARL O., A.M., Ph.D., Associate Professor of Biology, *Hamilton College, Griffin Road, College Hill, Clinton, N. Y.*

BUTLER, ELMER G., A.B., Ph.D., Associate Professor of Biology, *Laboratory of Comparative Anatomy, Princeton University, Princeton, N. J.*

CALKINS, LEROY A., M.S., M.D., Ph.D., Professor of Obstetrics and Gynecology, *University of Kansas Hospital, Kansas City, Kan.*

CAMERON, ANGUS L., A.B., M.S., M.D., Ph.D., *Northwest Clinic, Minot, N. Dak.*

CARDWELL, JOHN C., M.D., Professor of Physiology, Long Island College of Medicine, Science Laboratory, *112 Pacific St., Brooklyn, N. Y.*

CAREY, EBEN J., M.S., Sc.D., M.D., Professor of Anatomy and Director of Anatomy Department, Marquette University School of Medicine, *2028 N. 51st St., Milwaukee, Wis.*

CARPENTER, RUSSELL L., B.S., Ph.D., Associate in Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*

CARVER, GAIL L., A.B., A.M., Professor of Biology, Mercer University, *613 Orange St., Macon, Ga.*

CASAMAJOR, LOUIS, A.M., M.D., Professor of Neurology, *Columbia University, 630 West 168th St., New York City.*

CHAMBERS, ROBERT, JR., A.M., Ph.D., Research Professor of Biology and Chairman of the Department of Biology, *Washington Square College, New York University, New York City.*

CHANDLER, SIMON B., A.B., A.M., M.D., Associate Professor of Anatomy, Loyola University School of Medicine, *706 S. Lincoln St., Chicago, Ill.*

CHANG, CHUN, M.D., Associate Professor of Anatomy, *National Central University, College of Medicine, Woosung, Shanghai, China.*

CHARIPPER, HARRY A., B.S., M.S., Ph.D., Assistant Professor of Biology (Comparative Anatomy, Embryology, and Histology), *Washington Square College, New York University, New York City.*

CHARLES, CECIL M., A.B., M.A., Ph.D., Instructor, Department of Anatomy, *Washington University School of Medicine, St. Louis, Mo.*

CHARLTON, HARRY HAYWARD, A.B., A.M., Ph.D., Professor of Anatomy, *Department of Anatomy, University of Missouri, Columbia, Mo.*

CHASE, SAMUEL WOOD, A.B., A.M., Ph.D., Associate Professor of Histology and Embryology, *Western Reserve University, 2109 Adelbert Road, Cleveland, Ohio.*

CHIDESTER, FLOYD E., A.M., Ph.D., Professor of Zoölogy, *University of West Virginia, Morgantown, W. Va.*

CHILD, CHARLES MANNING, M.S., Ph.D., D.Sc., Professor of Zoölogy, *Zoölogical Laboratory, University of Chicago, Chicago, Ill.*

CHILLINGWORTH, FELIX P., M.D., Professor of Experimental Pharmacology, Tufts Medical College, *416 Huntington Ave., Boston, Mass.*

CHOUKE, KEHAR SINGH, M.A., M.D., Assistant Professor of Anatomy, *Colorado University Medical School, 4200 East Ninth Ave., Denver, Colo.*

CLARK, ELEANOR LINTON, A.M., Voluntary Research Worker, Department of Anatomy, *Medical Department, University of Pennsylvania, Philadelphia, Pa.*

CLARK, ELIOT R., A.B., M.D. (Ex. Com. '16–'19), Professor of Anatomy and Director of Department of Anatomy, University of Pennsylvania, *301 St. Mark's Square, Philadelphia, Pa.*

CLARK, SAM L., M.S., Ph.D., M.D., Associate Professor of Anatomy, *Vanderbilt University School of Medicine, Nashville, Tenn.*

COE, WESLEY R., Ph.D., Professor of Biology, *Yale University, Osborn Zoölogical Laboratory, New Haven, Conn.*

COGHILL, GEORGE E., A.B., M.S., Ph.D., Sc.D. (Ex. Com. '27–'31, Pres. '32–), Member of *The Wistar Institute of Anatomy and Biology, 36th Street and Woodland Ave., Philadelphia, Pa.*

COHN, ALFRED E., A.B., M.D., Member, *Rockefeller Institute for Medical Research, New York City, N. Y.*

COLE, ARCH EVAN, A.B., Ph.D.; Assistant Professor, Anatomy Department, *University of Louisville, Louisville, Kentucky.*

COLE, HAROLD H., Ph.D., Assistant Professor of Animal Husbandry, University of California, and Assistant Animal Husbandman, *Experiment Station of the College of Agriculture, Davis, Calif.*

COLLINGS, M. RAYMOND, M.D., Associate Professor of Anatomy, *Detroit College of Medicine and Surgery, Detroit, Mich.*

COLLINS, HENRY HOMER, Ph.D., Professor of Zoölogy, *University of Pittsburgh, Pittsburgh, Pa.*

COMAN, FRANCIS DANA, A.B., A.M., M.D., Assistant in Surgery, Johns Hopkins University, *Johns Hopkins Hospital, Baltimore, Md.*

CONANT, WILLIAM MERRITT, A.B., M.D., Surgeon, *636 Beacon St., Boston, Mass.*

CONEL, JESSE LEROY, A.M., Ph.D., Professor of Anatomy, Boston University School of Medicine, *80 E. Concord St., Boston, Mass.*

CONGDON, EDGAR DAVIDSON, Ph.D., *Alger Court, Pondfield Rd., Bronxville, N. Y.*

CONKLIN, EDWIN GRANT, A.M., Ph.D., Sc.D., LL.D., Professor of Biology, Princeton University, *139 Broadmead Ave., Princeton, N. J.*

COPENHAVER, WILFRED M., A.B., Ph.D., Assistant Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*

COREY, EDWARD LYMAN, A.B., Ph.D., Assistant Professor of Physiology, *University of Virginia, School of Medicine, Charlottesville, Va.*

CORNER, GEORGE W., A.B., M.D. (Ex. Com. '26–'30; Sec.-Treas. '30–), Professor of Anatomy, *University of Rochester, Crittenden Boulevard, Rochester, N. Y.*

CORNING, H. K., M.D., Professor of Anatomy, *University of Bâle, Anatomische Anstalt, Bâle, Pestalozzistr. 20, Switzerland.*

COVELL, W. P., M.S., Ph.D., Assistant, *Washington University School of Medicine, St. Louis, Mo.*

COWDRY, EDMUND V., Ph.D. (Ex. Com. '26–'30), Professor of Cytology, *Washington University Medical School, St. Louis, Missouri.*

CRAIGIE, E. HORNE, B.A., Ph.D., Assistant Professor of Comparative Anatomy and Neurology, *Department of Biology, University of Toronto, Toronto, 5, Canada.*

CRILE, GEORGE W., M.D., F.A.C.S., Professor Emeritus of Surgery, Western Reserve University, *Cleveland Clinic, 93rd and Euclid, Cleveland, Ohio.*

CROSBY, ELIZABETH CAROLINE, M.S., Ph.D., Associate Professor of Anatomy, University of Michigan, *201 N. Thayer St., Ann Arbor, Mich.*

CUAJUNCO, FIDEL, M.D., Assistant Professor of Anatomy, College of Medicine, University of the Philippines, *620 Colorado St., Manila, P. I.*

CULLEN, THOMAS S., M.B., D.Sc., LL.D. (Tor.), Professor of Clinical Gynecology, Johns Hopkins University, Gynecologist to the Johns Hopkins Hospital, *20 E. Eager St., Baltimore, Md.*

CUMMINS, HAROLD, A.B., Ph.D., Professor of Anatomy, *Tulane University Medical School, Department of Anatomy, Sta. 20, New Orleans, La.*

CUNNINGHAM, ROBERT S., B.S., A.M., M.D. (Ex. Com. '32–), Professor of Anatomy, *Vanderbilt University School of Medicine, Nashville, Tenn.*

CURTIS, GEORGE M., A.M., Ph.D., M.D., Associate Professor of Surgery, *Billings Memorial Hospital, University of Chicago, Chicago, Ill.*

DAHLGREN, ULRIC, A.B., M.S., Professor of Biology, Princeton University, *204 Guyot Hall, Princeton, N. J.*

DANFORTH, CHARLES HASKELL, A.M., Ph.D. (Ex. Com. '27–'31), Professor of Anatomy, Stanford University, *607 Cabrillo Ave., Stanford University, Calif.*

DARRACH, WILLIAM, A.B., A.M., M.D., Sc.D., LL.D., Professor of Clinical Surgery and Dean Emeritus of Faculty of Medicine, College of Physicians and Surgeons, Columbia University, *180 Fort Washington Ave., New York City.*

DART, RAYMOND A., M.D., Ch.M., M.Sc., Professor of Anatomy and Dean of Faculty of Medicine, *University of the Witwatersrand, Johannesburg, Transvaal, South Africa.*

DAVENPORT, H. A., M.D., Associate Professor of Anatomy, *Northwestern University Medical School, Chicago, Illinois.*

DAVIS, CARL L., M.D., Professor of Anatomy, University of Maryland School of Medicine, *Lombard and Greene Streets, Baltimore, Md.*

DAVIS, WARREN B., M.D., F.A.C.S., Assistant Professor of Oral Surgery, Jefferson Medical College; Chief Maxillo-Facial Clinic, Jefferson Hospital; Consulting Maxillo-Facial Surgeon, Kensington Hospital; Consulting Otolaryngologist, St. Agnes Hospital; Assistant Surgeon, Frankford Hospital; *135 S. 18th St., Philadelphia, Pa.*

DAWSON, ALDEN B., A.B., Ph.D., Associate Professor of Zoölogy, Zoölogical Laboratory, *Biological Laboratories, Harvard University, Cambridge, Mass.*

DE CARLO, JOHN, M.D., Associate in Topographic and Applied Anatomy, Jefferson Medical College, *1629 S. Broad St., Philadelphia, Pa.*

DEES-MATTINGLY, MARIE, A.B., B.S., M.D., Assistant Professor of Anatomy, *Tulane University of Louisiana, New Orleans, La.*

DE GARIS, CHARLES F., A.B., M.D., Ph.D., Associate in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

DETWILER, SAMUEL RANDALL, Ph.B., A.M., Ph.D., M.S. (Hon.) (Ex. Com. '30–), Professor of Anatomy, Department of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*

DIXON, A. FRANCIS, M.B., Sc.D., University Professor of Anatomy, Trinity College, *42 Elgin Road, Dublin, Ireland.*

DOAN, CHARLES A., B.S., M.D., Director, Department of Medical and Surgical Research, Ohio State University, *Kinsman Hall, Columbus, Ohio.*

DODDS, GIDEON S., A.M., Ph.D., Professor of Histology and Embryology, *West Virginia University Medical School, Morgantown, W. Va.*

DODSON, JOHN MILTON, A.M., M.D., Sc.D., Professor (Emeritus) of Medicine, Rush Medical College, *Hyde Park Hotel, Chicago, Ill.*

DONALDSON, HENRY HERBERT, Ph.D., D.Sc. (Ex. Com. '09–'13, Pres. '16–'17), Member of The Wistar Institute, *The Wistar Institute of Anatomy and Biology, Woodland Ave. and Thirty-sixth St., Philadelphia, Pa.*

DONALDSON, JOHN C., Ph.B., M.D., Professor of Anatomy, *School of Medicine, University of Pittsburgh, Pittsburgh, Pa.*

DOWNEY, HAL, A.M., Ph.D., Professor of Anatomy, *University of Minnesota Medical School, Minneapolis, Minn.*

DOWNS, WILLIAM GERSHOM, JR., A.B., A.M., D.D.S., Ph.D., Associate Professor of Pathology, Chicago Medical School, *710 S. Lincoln St., Chicago, Ill.*

DUBOIS, FRANKLIN S., A.B., M.S., M.D., Assistant Professor and Acting Head, *Department of Anatomy, University of Alabama, University, Ala.*

Duesberg, Jules, M.D., Professor of Anatomy, *University of Liege, 22 quai Mativa, Liege, Belgium.*

Duncan, Donald, A.B., A.M., Ph.D., Associate Professor of Anatomy, *Universty of Texas, Galveston, Tex.*

Dunn, H. L., B.A., M.A., M.B., Ph.D., M.D., Director of University Hospital and Professor of Medical Statistics, *University of Minnesota, Minneapolis, Minn.*

Eccles, Robert G., M.D., Phar.D., *681 Tenth St., Brooklyn, N. Y.*

Edwards, J. Graham, M.A., Ph.D., Assistant Professor of Anatomy, University of Buffalo School of Medicine, *24 High Street, Buffalo, N. Y.*

Edwards, Linden F., B.A., M.S., Ph.D., Assistant Professor of Anatomy, Ohio State University College of Medicine, *Hamilton Hall, Columbus, Ohio.*

Elwyn, Adolph, A.M., Assistant Professor of Neurology, *Columbia University, 630 West 168th St., New York City.*

Engle, Earl Theron, A.B., A.M., Ph.D., Associate Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 632 West 168th St., New York City.*

Esaki, Shiro, Assistant Professor of Anatomy, *Keio-Gigyuku University, Yotsuya, Tokyo, Japan.*

Essick, Charles Rhein, B.A., M.D., *439 Oley St., Reading, Pa.*

Evans, Herbert McLean, B.S., M.D., M.D. honoris causa, Freiburg (Ex. Com. '19–'22; Pres. '30–'32), Hertzstein Professor of Biology, Professor of Anatomy, Chairman of Department of Anatomy, and Director of Institute of Experimental Biology, *University of California, Berkeley, Calif.*

Evans, Thomas Horace, M.D., Associate Professor of Anatomy, Long Island College Hospital, *350 S. Main St., Freeport, N. Y.*

Faris, Hervey S., A.B., A.M., Ph.D., M.D., Practicing Physician and Surgeon, *3616 Main St., Riverside, Calif.*

Ferris, Harry Burr, A.B., M.D., E. K. Hunt Professor of Anatomy, Medical Department, Yale University, *395 St. Ronan St., New Haven, Conn.*

Fischelis, Philipp, M.D., Professor of Histology, Embryology, and General Pathology, Philadelphia Dental College of Temple University, *2132 N. 19th St., Philadelphia, Pa.*

Flexner, Louis Barkhouse, S.B., M.D., Instructor in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

Foley, James Owen, M.S., Ph.D., Assistant Professor of Anatomy, *University of Alabama School of Medicine, University, Ala.*

Forman, Jonathan, A.B., M.D., Director of Pathological Laboratories, Grant Hospital, *394 East Town St., Columbus, Ohio.*

Frassetto, Fabio, Sc.D., M.D., Director Anthropological Institute, *University of Bologna, Bologna, Italy.*

Fraser, Doris A., Ph.D., Fellow in Anatomy, *University of Pennsylvania School of Medicine, Philadelphia, Pa.*

Frazer, John Ernest, M.D., F.R.C.S., Professor of Anatomy, University of London, *St. Mary's Hospital Medical School, London, W., England.*

French, H. E., M.S., M.D., Professor of Anatomy and Dean of the School of Medicine, *University of North Dakota, Grand Forks, North Dakota.*

FREUDENBERGER, CLAY B., Ph.D., Professor of Anatomy, *University of Utah, Salt Lake City, Utah.*

GAGE, SIMON HENRY, B.S. (Ex. Com. '06–'11), Professor of Histology and Embryology, Emeritus, *Stimson Hall, Cornell University, Ithaca, N. Y.*

GALLAUDET, BERN BUDD, A.B., A.M., M.D., Associate Professor of Anatomy, Columbia University, Consulting Surgeon, Bellevue Hospital, *601 West 168th St., New York City.*

GAMBLE, DEAN L., B.S., Ph.D., President, Ward's Natural Science Establishment, *302 North Goodman St., Rochester, N. Y.*

GARCIA, ARTURO, A.B., M.D., Professor of Anatomy and Head of Department, College of Medicine, University of the Philippines, *619 Colorado St., Manila, Philippine Islands.*

GEIST, FREDERICK D., M.D., Assistant Professor of Anatomy, *University of Wisconsin, Science Hall, Madison, Wis.*

GEORGE, RUGGLES KERR, B.A., M.B., D.P.H., Special Lecturer in Anatomy, *University of Toronto, Toronto 5, Canada.*

GEORGE, WESLEY CRITZ, A.B., A.M., Ph.D., Professor of Histology and Embryology, *University of North Carolina Medical School, Chapel Hill, N. C.*

GERSCH, ISIDOR, B.S., Ph.D., Fellow of the Rockefeller Foundation, *Department of Anatomy, University of Chicago, Chicago, Ill.*

GILLASPIE, C., M.D., F.A.C.S., Associate Professor of Anatomy, *University of Colorado, Boulder, Colo.*

GLOBUS, J. H., B.S., M.D., Associate Professor of Neuro-anatomy and Neuropathology, New York University and Bellevue Medical College, *1185 Park Ave., New York City.*

GOSS, CHARLES MAYO, A.B., M.D., Assistant Professor of Anatomy, College of Physicians and Surgeons, Columbia University, *630 West 168th St., New York City.*

GOULD, HARLEY NATHAN, A.B., A.M., Ph.D., Professor of Biology, *Newcomb College, Tulane University, New Orleans, La.*

GRAFFLIN, ALLAN L., A.B., M.D., Instructor in Anatomy, *Harvard Medical School, Boston, Mass.*

GRANT, J. C. BOILEAU, M.B., Ch.B., F.R.C.S. (Edin.), Professor of Anatomy, *University of Toronto, Toronto, Canada.*

GRANT, MADELEINE P., S.B., M.A., Ph.D., Assistant Professor of Zoölogy, *Smith College, Northampton, Mass.*

GRAVES, WILLIAM W., M.D., Professor and Director, Department of Neuropsychiatry, *St. Louis University School of Medicine, St. Louis, Mo.*

GREENE, CHARLES W., A.M., Ph.D., Professor of Physiology and Pharmacology, University of Missouri, *814 Virginia Ave., Columbia, Mo.*

GREENE, WALTER FARRAR, A.B., Ph.D., Associate Professor of Anatomy, *Syracuse College of Medicine, 309 South McBride St., Syracuse, N. Y.*

GREENHILL, J.P., B.S., M.D., F.A.C.S., Associate Professor of Gynecology, Loyola University Medical School; Professor of Gynecology, Cook County Graduate School of Medicine; Attending Gynecologist, Cook County Hospital, *185 N. Wabash Ave., Chicago, Ill.*

GREENMAN, MILTON J., Ph.B., M.D., Sc.D., Director of *The Wistar Institute of Anatomy and Biology, 36th St. and Woodland Ave., Philadelphia, Pa.*

GREGORY, WILLIAM KING, A.B., A.M., Ph.D., Professor of Vertebrate Palaeontology, Columbia; Curator Departments of Comparative Anatomy and Ichthyology, Research Associate in Anthropology and Palaeontology, *American Museum of Natural History, New York City.*

GRODINSKY, MANUEL, B.Sc., M.D., Assistant Professor of Anatomy, University of Nebraska, College of Medicine, *631 N. 58th St., Omaha, Neb.*

GUDERNATSCH, F., Ph.D., Visiting Professor, Graduate School, *New York University, Washington Square East, New York City.*

GUILD, STACY R., A.M., Ph.D., Associate Professor of Otology and Director of Otological Research Laboratory, Johns Hopkins University, *Johns Hopkins Hospital, Baltimore, Md.*

GURDJIAN, ELISHA STEPHENS, A.B., M.S., M.D., Ph.D., Neuro-Surgeon, Receiving and Harper Hospitals, *840 David Whitney Bldg., Detroit, Mich.*

GUTHRIE, MARY J., A.B., A.M., Ph.D., Associate Professor of Zoölogy, *University of Missouri, Columbia, Mo.*

GUTTMACHER, ALAN F., A.B., M.D., Associate in Obstetrics, Johns Hopkins University, *824 Park Ave., Baltimore, Md.*

GUYER, MICHAEL F., Ph.D., LL.D., Professor of Zoölogy, *University of Wisconsin, Madison, Wis.*

HALL, BYRON E., Teaching Fellow in Anatomy, *University of Minnesota Medical School, Minneapolis, Minn.*

HALL, EDMUND K., D.Sc., Ph.D., Instructor in Anatomy, *University of Louisville Medical School, Louisville, Ky.*

HALL, E. RAYMOND, Ph.D., Assistant Professor of Vertebrate Zoölogy, Curator of Mammals, *California Museum of Vertebrate Zoölogy, University of California, Berkeley, Calif.*

HALPERT, BÉLA, M.D., Instructor in Surgical Pathology, Laboratory of Pathology, *Yale University Medical School, New Haven, Conn.*

HANAN, ERNEST B., A.B., A.M., M.D., Assistant Professor in Anatomy; Director of Laboratories of Buffalo City Hospital, *University of Buffalo, Buffalo, N. Y.*

HANSON, FRANK BLAIR, A.B., A.M., Ph.D., Professor of Zoölogy, *Washington University, St. Louis, Mo.*

HARDESTY, IRVING, A.B., Ph.D., Sc.D. (Ex. Com. '10 and '12–'15, '22–'23), Professor of Anatomy and Head of Department of Anatomy, School of Medicine, *Tulane University, P. O. Station 20, New Orleans, La.*

HARE, EARLE R., A.B., M.D., F.A.C.S., *730 LaSalle Building, Minneapolis, Minn.*

HARGITT, GEORGE T., A.B., A.M., Ph.D., Professor of Zoölogy, *Duke University, Durham, N. C.*

HARRIS, HENRY A., M.B., B.S., F.Z.S., M.R.C.S., L.R.C.P., D.Sc., Professor of Clinical Anatomy, *Institute of Anatomy, University College and University College Hospital, Gower St., London, W.C.1, England.*

HARRISON, ROSS GRANVILLE, Ph.D., M.D., Sc.D. (Pres. '12–'14), Sterling Professor of Biology and Director of Osborn Zoölogical Laboratory, *Yale University, New Haven, Conn.*

HARTMAN, CARL G., Ph.D. (Ex. Com. '29–'33), Research Associate, *Carnegie Laboratory of Embryology, Johns Hopkins Medical School, Baltimore, Md.*

HARVEY, BASIL COLEMAN HYATT, A.B., M.B., Professor of Anatomy and Dean of Students, Division of Biological Sciences, *University of Chicago, Chicago, Ill.*

HARWELL, CHARLES W., A.B., M.D., Assistant Professor of Micro-anatomy, *Emory University, Emory, Ga.*

HATERIUS, HANS OLIVER, A.B., M.S., Ph.D., Assistant Professor of Biology, *Washington Square College, New York University, New York City.*

HATT, ROBERT T., Sc.B., M.A., Ph.D., Assistant Curator, Department of Mammalogy, *American Museum of Natural History, New York City.*

HAUSMAN, LOUIS, A.B., M.D., Associate in Neuro-anatomy, Cornell Medical School, *1175 Park Ave., New York City.*

HAZEN, CHARLES MORSE, A.M., M.D., *Professional Building, Fifth and Franklin Sts., Richmond, Va.*

HEINBECKER, PETER, M.D., Assistant Professor of Surgery, *Washington University Medical School, St. Louis, Missouri.*

HEISLER, JOHN C., M.D., Emeritus Professor of Anatomy, University of Pennsylvania, *3829 Walnut St., Philadelphia, Pa.*

HELDT, THOMAS JOHANES, A.B., A.M., M.D., Physician in Charge of Neuropsychiatric Division, *Henry Ford Hospital, Detroit, Mich.*

HELFF, O. M., B.S., M.S., Ph.D., Associate Professor of Biology, *New York University, New York City.*

HERRICK, CHARLES JUDSON, Ph.D. (Ex. Com. '13–'17), Professor of Neurology, University of Chicago, *Department of Anatomy, University of Chicago, Chicago, Ill.*

HERTZLER, ARTHUR E., B.S., A.M., Ph.D., M.D., LL.D., F.A.C.S., Professor of Surgery, *University of Kansas, Halstead, Kansas.*

HETHERINGTON, DUNCAN CHARTERIS, A.B., M.A., Ph.D., M.D., Associate Professor of Anatomy, *Duke University Medical School, Durham, N. C.*

HEUSER, CHESTER H., A.M., Ph.D., Research Associate, Department of Embryology, Carnegie Institution, *Johns Hopkins Medical School, Baltimore, Md.*

HEWSON, ADDINELL, A.B., A.M., M.D., F.A.C.S., Emeritus Professor of Anatomy, Graduate School of Medicine, University of Pennsylvania, and Professor of Anatomy and Histology, Temple University Dental School; Secretary Anatomical Board of the State of Pennsylvania, *257 South 16th Street, Philadelphia, Pa.*

HIGGINS, GEORGE M., A.M., Ph. D., Associate Professor of Experimental Biology, *University of Minnesota, Mayo Foundation, Rochester, Minn.*

HILL, EBEN CLAYTON, A.B., M.D., Lecturer in Roentgenological Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

HILL, JAMES PETER, D.Sc., F.R.S., Professor of Embryology, University of London, *University College, Gower St., London., W. C. 1, England.*

HILTON, WILLIAM A., B.S., Ph.D., Professor of Zoölogy, Pomona College, Director *Laguna Marine Laboratory, Claremont, Calif.*

HINES, MARION, A.B., Ph.D., Associate Professor of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

HINSEY, JOSEPH C., M.S., Ph.D., Professor of Anatomy, Department of Anatomy, *Stanford University, Calif.*

HIRSCH, G. CHRISTIAN, Ph.D., Lector, Head of Department of Experimental Histology, *Zoölogical Laboratory, The University, Utrecht, Fjanskerkhof 3, Holland.*

HISAW, FREDERICK L., A.B., A.M., Ph.D., Professor of Zoölogy, *University of Wisconsin, Madison, Wis.*

HOADLEY, LEIGH, A.B., Ph.D., Professor of Zoölogy, *Harvard University, Cambridge, Mass.*

HOERR, NORMAND L., B.A., Ph.D., M.D., Instructor in Anatomy, *University of Chicago, Chicago, Ill.*

HOGG, IRA D., B.A., M.A., Ph.D., Assistant Professor of Anatomy, Department of Anatomy, University of Pittsburgh School of Medicine, *115 Peebles St., Pittsburgh, Pa.*

HOGUE, MARY J., Ph.D., Instructor in Histology, *University of Pennsylvania Medical School, Philadelphia, Pa.*

HOLLINSHEAD, WILLIAM H., A.B., M.S., Ph.D., Instructor in Anatomy, *Duke University Medical School, Durham, N. C.*

HOLT, CAROLINE M., A.B., A.M., Ph.D., Associate Professor of Biology and Public Health, Simmons College, *130 Elgin St., Newton Centre, Mass.*

HOOKER, DAVENPORT, M.A., Ph.D. (Ex. Com. '22–'25), Professor of Anatomy, *School of Medicine, University of Pittsburgh, Pittsburgh, Pa.*

HOPKINS, GRANT SHERMAN, Sc.D., D.V.M., Professor Comparative Veterinary Anatomy, *Cornell University, Ithaca, N. Y.*

HORNING, ERIC S., D.Sc., Cytologist Cancer Research Committee, Department of Anatomy, *Universty of Sydney, Sydney, N.S.W., Australia.*

HOSKINS, MARGARET MORRIS, Ph.D., Associate Professor of Microscopic Anatomy, *New York University Dental College, 209 East Twenty-third St., New York City.*

HOWELL, A. BRAZIER, A.B., Associate Professor of Comparative Anatomy, *Department of Anatomy, Johns Hopkins Medical School, Baltimore, Md.*

HOWLAND, RUTH B., Ph.D., Associate Professor of Biology, Washington Square College, *New York University, Washington Square East, New York City.*

HOY, WM. E., JR., A.B., Ph.D., Professor of Biology and Head of the Department of Biology, University of South Carolina, *2318 Wheat St., Columbia, S. C.*

HRDLIČKA, ALEŠ, M.D., Sc.D., Curator, Division of Physical Anthropology, *United States National Museum, Smithsonian Institution, Washington, D. C.*

HUBER, G. CARL, M.D., Sc.D. (Second Vice-Pres. '00–'01, Secretary-Treasurer '02–'14, Pres. '14–'16, Ex. Com. '20–'23), Professor of Anatomy and Director of the Anatomical Laboratories, Dean of the Graduate School, University of Michigan, *1330 Hill St., Ann Arbor, Mich.*

HUGHSON, WALTER, S.B., M.D., Associate in Research Otology, Assistant Visiting Surgeon, Johns Hopkins Hospital, *1411 Eutaw Place, Baltimore, Md.*

HUMPHREY, RUFUS R., A.B., A.M., Ph.D., Associate Professor of Anatomy, School of Medicine, University of Buffalo, *24 High St., Buffalo, N. Y.*

HUNT, THOMAS E., Ph.D., Assistant Professor of Anatomy, *University of Alabama Medical School, University, Ala.*

HUNTER, OSCAR B., A.B., A.M., M.D., Assistant Dean and Professor of Pathology and Bacteriology, *George Washington Medical School, 1335 H St., N.W., Washington, D. C.*

HUNTER, RICHARD HENRY, Ph.D., M.D., M.Ch., F.Z.S., Senior Lecturer in Anatomy, *Department of Anatomy, Queen's University, Belfast, Ireland.*

INGALLS, N. WILLIAM, B.S., M.D., Associate Professor of Anatomy, School of Medicine, Western Reserve University, *2109 Adelbert Road, Cleveland, Ohio.*

INGRAM, W. R., Ph.D., Assistant Professor of Neurology, Northwestern University Medical School, Institute of Neurology, *303 E. Chicago Ave., Chicago, Ill.*

INGVAR, SVEN, M.D., Professor of Internal Medicine, *University of Lund, Lund, Sweden.*

JACKSON, CLARENCE M., M.S., M.D., LL.D. (Ex. Com. '10–14, '23–'28, Vice-Pres. '16–'17, Pres. '22–'23), Professor and Director of the Department of Anatomy, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

JENKINS, GEORGE B., M.D., Professor of Anatomy and Director of Anatomy Department, *George Washington University Medical School, Washington, D. C.*

JOB, THESLE T., A.B., M.S., Ph.D., Professor of Anatomy, *Loyola University School of Medicine, 706 South Lincoln St., Chicago, Ill.*

JOHNSON, CHARLES EUGENE, A.M., Ph.D., Head of Department and Professor of Zoölogy and Director of the Roosevelt Wild Life Forest Experiment Station, *Department of Forest Zoölogy, State College of Forestry, Syracuse, N. Y.*

JOHNSON, FRANKLIN P., A.M., Ph.D., M.D., Assistant Professor of Urology, University of Oregon Medical School, *316 Medical Arts Building, Portland, Ore.*

JOHNSON, SYDNEY E., Ph.D., M.D., Professor of Gross Anatomy, School of Medicine, University of Louisville, *101 West Chestnut St., Louisville, Ky.*

JOHNSTON, JOHN B., Ph.D., Dean of the College of Science, Literature and the Arts, Professor of Comparative Neurology, *University of Minnesota, Minneapolis, Minn.*

JOHNSTON, THOMAS BAILLIE, M.B., Ch.B., Professor of Anatomy, University of London, *Guy's Hospital Medical School, London, S. E. 1, England.*

JOHNSTONE, PAUL N., A.B., M.D., *601 Lathrop Building, Kansas City, Mo.*

JORDAN, HARVEY ERNEST, A.M., Ph.D. (Ex. Com. '18–'21), Professor of Histology and Embryology, *Department of Medicine, University of Virginia, Charlottesville, Va.*

KAAN, HELEN WARTON, Ph.D., Assistant Professor of Zoölogy, *Wellesley College, Wellesley, Mass.*

KAMPMEIER, OTTO FREDERIC, A.B., Ph.D., M.D., Professor of Anatomy and Head of Department, *College of Medicine, University of Illinois, 1853 W. Polk St., Chicago, Ill.*

KAPPERS, CORNELIUS URBO ARIËNS, M.D., Sc.D., L.D., Director of the Central Institute for Brain Research of Holland; Professor of Comparative Neurology, University of Amsterdam, *Mauritskade 61, Amsterdam, Holland.*

KEEGAN, J. JAY, A.M., M.D., Professor of Neurological Surgery, University of Nebraska College of Medicine, *1234 Medical Arts Building, Omaha, Neb.*

KEITH, ARTHUR, M.D., LL.D., F.R.C.S., F.R.S., Hunterian Professor of Anatomy. *Royal College of Surgeons, Lincoln's Inn Fields, London, W. C. 2, England.*

KELLOGG, HOWARD BUTTERS, B.S., M.S., Ph.D., M.D., Associate Medical Officer U.S.V.B., Department of Surgery, Edward Hines Hospital, Hines, Illinois, *1918 South 7th Ave., Maywood, Ill.*

KELLOGG, REMINGTON, Ph.D., Assistant Curator of Mammals, *U. S. National Museum, Washington, D. C.*

KELLY, G. LOMBARD, A.B., B.S., M.D., Professor of Anatomy, *University of Georgia, Medical Department, Augusta, Georgia.*

KERNAN, JOHN D., JR., A.B., M.D., Associate Professor of Oto-Laryngology, Columbia College of Physicians and Surgeons, *120 East Seventy-fifth St., New York City.*

KERR, ABRAM T., B.S., M.D. (Ex. Com. '10–'14), Professor of Anatomy and Secretary of Cornell University Medical College, *Cornell University Medical College, Ithaca, N. Y.*

KEY, J. ALBERT, B.S., M.D., Clinical Professor of Orthopedic Surgery, *Washington University, St. Louis, Mo.*

KINDRED, JAMES ERNEST, A.B., A.M., Ph.D., Associate Professor of Histology and Embryology, *University of Virginia Medical School, University, Va.*

KING, HELEN DEAN, A.M., Ph.D., Member of The Wistar Institute (Experimental Zoölogy), *The Wistar Institute of Anatomy, 36th St. and Woodland Ave., Philadelphia, Pa.*

KING, JESSIE L., Ph.D., Professor of Physiology, *Goucher College, Baltimore, Md.*

KINGERY, HUGH MCMILLAN, A.B., A.M., Ph.D., Associate Professor of Anatomy, *School of Medicine, University of Colorado, Denver, Col.*

KINGSBURY, BENJAMIN F., A.B., Ph.D., M.D. (Ex. Com. '22–'25, Vice-Pres. '32–), Professor of Histology and Embryology, Cornell University, *2 South Ave., Ithaca, N. Y.*

KIRKHAM, WILLIAM BARRI, Ph.D., Consulting Director, Museum of Natural History, *275 Maple St., Springfield, Mass.*

KNOUFF, R. A., B.A., M.A., Ph.D., Professor of Anatomy, *Department of Anatomy, Ohio State University, Columbus, Ohio.*

KNOWER, HENRY MCE., A.B., Ph.D. (Ex. Com. '11–'15, '24–'26), Research Fellow in Zoölogy, *Osborn Zoölogical Laboratory, Yale University, New Haven, Conn.*

KOCH, JOHN C., B.S., M.D., Junior Physician, Harper Hospital, *265 Euclid Ave., East, Detroit, Mich.*

KOFOID, CHARLES ATWOOD, A.B., Ph.D., Sc.D., Professor of Zoölogy and Chairman of Department, *Room 4079, Life Sciences Bldg., University of California, Berkeley, Calif.*

KORNHAUSER, S. I., M.A., Ph.D., Professor of Anatomy and Executive Secretary, *University of Louisville, Medical School, Louisville, Ky.*

KRAFKA, JOSEPH, JR., Ph.D., Associate Professor of Anatomy, Medical Department, *University of Georgia, Augusta, Ga.*

KRAUSE, ALLEN KRAMER, A.B., A.M., M.D., President and Director, *The Desert Sanatorium, Tucson, Arizona.*

KROGMAN, WILTON M., Ph.D., Associate Professor of Physical Anthropology, *Western Reserve University, Cleveland, Ohio.*

KUDO, TOKUYASU, M.D., Professor of Anatomy and Histology, *Niigata Medical College, Niigata City, Echigo, Japan.*

KUNITOMO, KANAE, M.D., Professor of Anatomy, *Anatomical Institute, Nagasaki Medical School, Nagasaki, Japan.*

KUNKEL, BEVERLY WAUGH, Ph.B., Ph.D., Professor of Biology, *Lafayette College, Easton, Pa.*

KUNTZ, ALBERT, Ph.D., M.D., Professor of Micro-anatomy, *St. Louis University Medical School, 1402 South Grand Ave., St. Louis, Mo.*

KUTCHIN, MRS. HARRIET LEHMANN, A.M., *"The Maplewood," Green Lake, Wis.*

LAMBERT, AVERY ELDORUS, B.S., Ph.D., Professor of Histology, State University of Iowa Medical School, *Room 360, Medical Laboratories Bldg., Iowa City, Iowa.*

LANDACRE, FRANCIS LEROY, Ph.D., Professor of Anatomy and Head of Department, Ohio State University, *2026 Inka Ave., Columbus, Ohio.*

LANGWORTHY, ORTHELLO R., A.B., A.M., M.D., Associate Professor of Neurology, Johns Hopkins University, *Johns Hopkins Hospital, Baltimore, Md.*

LARSELL, OLOF, A.M., Ph.D., Professor of Anatomy, *University of Oregon Medical School, Portland, Oregon.*

LATIMER, HOMER B., A.M., Ph.D., Professor of Anatomy, *Medical School, University of Kansas, Lawrence, Kansas.*

LATTA, JOHN S., A.B., Ph.D., Professor of Anatomy, University of Nebraska, College of Medicine, *Forty-second St. and Dewey Ave., Omaha, Neb.*

LEE, FERDINAND CHRISTIAN, A.B., M.D., Associate in Surgery, *Johns Hopkins Hospital, Baltimore, Md.*

LEVI, GIUSEPPE, M.D., Professor of Anatomy, *University of Torino, Istituto anatomico, Corso d'Azeglio 52, Torino, Italy.*

LEWIS, DEAN D., M.D., Sc.D., LL.D., Professor of Surgery, Johns Hopkins University, *Johns Hopkins Hospital, Baltimore, Md.*

LEWIS, FREDERIC T., A.M., M.D. (Ex. Com. '09–'13, Vice-Pres. '14–'16), Professor of Comparative Anatomy, *Harvard Medical School, Boston, Mass.*

LEWIS, MARGARET REED, M.A., Research Associate, Department of Embryology, Carnegie Institution of Washington, *Johns Hopkins Medical School, Baltimore, Md.*

LEWIS, WARREN HARMON, B.S., M.D. (Ex. Com. '09–'11, '14–'17), Research Associate, Department of Embryology, Carnegie Institution, Professor of Physiological Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

LILLIE, FRANK RATTRAY, Ph.D., Sc.D., Dean of Division of Biological Sciences, Professor of Embryology, Department of Zoölogy, University of Chicago; President of Marine Biological Laboratory, Woods Hole, Mass., *University of Chicago, Chicago, Ill.*

LINEBACK, PAUL EUGENE, A.M., M.D., Professor of Micro-anatomy, *Atlanta Medical College, Emory University, Ga.*

LINELL, ERIC AMBROSE, Ch.B., M.D., Professor of Neuropathology, *Banting Institute, University of Toronto, Canada.*

LIPSCHUTZ, BENJAMIN, M.D., Associate in Neuro-anatomy, Jefferson Medical College, *1007 Spruce St., Philadelphia, Pa.*

LITTLE, CLARENCE COOK, B.A., M.S., Sc.D., LL.D., Litt.D., *Jackson Memorial Laboratory, Bar Harbor, Me.*

LOOPER, JAMES BURDINE, B.S., M.S., Ph.D., Associate Professor of Histology and Embryology, *Box 55, University of Mississippi, University, Miss.*

LORD, FREDERIC P., A.B., M.D., Professor of Anatomy, *Dartmouth Medical School, 39 College St., Hanover, N. H.*

LOTH, EDWARD, M.D., Ph.D., Professor of Anatomy and Director of Anatomical Institute, University of Warsaw, *5 Chalubinski Str., Warsaw, Poland.*

LOWREY, LAWSON GENTRY, A.M., M.D., Director, Institute for Child Guidance, *9th Floor, 145 East 57th Street, New York City.*

LUCAS, ALFRED M., Ph.D., Assistant Professor of Cytology, *Washington University Medical School, St. Louis, Mo.*

LUCAS, MIRIAM SCOTT, Ph.D., Instructor in Cytology, *Washington University School of Medicine, St. Louis, Mo.*

Lyons, William R., Ph.D., Instructor in Anatomy, *University of California, Berkeley, Calif.*

MacCallum, Daniel Bartlett, S.B., Ph.D., M.D., Associate Professor of Anatomy, *University of Southern California Medical School, Los Angeles, Calif.*

MacEwen, Ewen, B.S., M.S., M.D., Professor of Anatomy, Director of the Anatomical Laboratories, *University of Iowa, Iowa City, Iowa.*

MacFarland, Frank Mace, A.M., Ph.D., Professor of Histology, Leland Stanford Junior University, *775 Santa Ynez Street, Stanford University, Calif.*

McClendon, Jesse F., Ph.D., Professor of Physiological Chemistry, University of Minnesota, *815 Fulton St. S. E., Minneapolis, Minn.*

McClung, Clarence E., Ph.G., A.B., A.M., Ph.D., Professor of Zoölogy and Director of the Zoölogical Laboratory, *University of Pennsylvania, Philadelphia, Pa.*

McClure, Charles Freeman Williams, A.M., Sc.D. (Vice-Pres. '10–'11, Ex. Com. '12–'16, Pres. '20–'21), Professor of Comparative Anatomy, *Princeton University, Princeton, N. J.*

McCotter, Rollo E., M.D., Professor of Anatomy, Medical School, University of Michigan, *Lakewood Rl, Ann Arbor, Mich.*

McFall, Claude M., Ph.D., Assistant Professor of Biology, School of Histology and Embryology, *University of Virginia, Charlottesville, Va.*

McGill, Caroline, A.B., A.M., Ph.D., M.D., Physician, *58 W. Quartz, Butte, Mont.*

McKibben, Paul S., Ph.D., LL.D. (Ex. Com. '31–), Professor of Anatomy, *University of Southern California, Los Angeles, Calif.*

McKinney, Roscoe L., Ph.D., Professor of Anatomy, *Howard University, Washington, D. C.*

McMurrich, James Playfair, A.M., Ph.D., LL.D. (Ex. Com. '06–'07, '17–'20, Pres. '08–'09), Professor Emeritus of Anatomy, *University of Toronto, Toronto, Canada.*

McNutt, G. W., D.V.M., Assistant Professor of Veterinary Anatomy, *College of Veterinary Medicine, Washington State College, Pullman, Wash.*

Macklin, C. C., M.B., M.D., M.A., Ph.D., F.R.S.C. (Ex. Com. '28–'32), Professor of Histology and Embryology, *University of Western Ontario Medical School, London, Ontario, Canada.*

Maclean, Bernice L., A.B., Ph.D., Research Assistant in Ophthalmology, Columbia University, *630 W. 168th St., New York City.*

Magath, Thomas Byrd, M.S., Ph.D., M.D., Consulting Physician, Clinical Laboratories, Mayo Clinic, and Associate Professor of Pathology, University of Minnesota, *Mayo Clinic, Rochester, Minn.*

Mainland, Donald, M.B., Ch.B., D.Sc., *Department of Anatomy, Dalhousie University, Halifax, Nova Scotia, Canada.*

Malone, Edward F., A.B., M.D. (Ex. Com. '31–), Francis Brunning Professor of Anatomy, *University of Cincinnati, College of Medicine, Eden Ave., Cincinnati, Ohio.*

Mangum, Charles S., A.B., M.D., Professor of Anatomy, University of North Carolina, *510 East Franklin St., Chapel Hill, N. C.*

Mark, Edward Laurens, Ph.D., LL.D., Hersey Professor of Anatomy (Emeritus), Harvard University, and Trustee of the Bermuda Biological Station for Research, Inc., *109 Irving St., Cambridge, Mass.*

MARKEE, J. E., Ph.D., Assistant Professor of Anatomy, *Stanford University, Stanford, Calif.*

MASON, KARL E., Ph.D., Associate Professor of Anatomy, *Vanderbilt University Medical School, Nashville, Tenn.*

MASTIN, EDWARD V., M.S., M.D., Instructor in Anatomy, *Washington University, 908 Beaumont Medical Bldg., St. Louis, Mo.*

MATAS, RUDOLPH, M.D., LL.D., Emeritus Professor of Surgery and Demonstrator of Anatomy, Tulane University of Louisiana, *2255 St. Charles Ave., New Orleans, La.*

MATTHEWS, SAMUEL A., M.A., Ph.D., Associate in Anatomy, *University of Pennsylvania, School of Medicine, Philadelphia, Pa.*

MAVOR, JAMES WATT, B.A., M.A., Ph.D., Professor of Biology, *Union College, Schenectady, N. Y.*

MEAD, HAROLD TUPPER, B.A., M.S., Professor of Zoölogy, *Hartwick College, Oneonta, N. Y.*

MEAKER, SAMUEL R., A.B., M.D., M.R.C.S. (Eng.), F.A.C.S., F.C.O.G., Professor of Gynaecology, Boston University School of Medicine, *475 Commonwealth Ave., Boston, Mass.*

MEYER, ADOLF, M.D., LL.D., Professor of Psychiatry and Director of the Phipps Psychiatric Clinic, *Johns Hopkins Hospital, Baltimore, Md.*

MEYER, ARTHUR W., S.B., M.D. (Ex. Com. '12–'16, Vice-Pres. '24–'25), Professor of Anatomy, Leland Stanford Junior University, *121 Waverly St., Palo Alto, Calif.*

MEYER, ROLAND K., A.B., Ph.D., Fellow in Anatomy, *University of Rochester, Crittenden Boulevard, Rochester, N. Y.*

MICHELS, NICHOLAS A., M.A., D.Sc., Associate Professor of Anatomy, *The Daniel Baugh Institute of Anatomy, Jefferson Medical College, Philadelphia, Pa.*

MILLER, ADAM M., A.M., Dean and Professor of Anatomy, Long Island College of Medicine, *350 Henry St., Brooklyn, N. Y.*

MILLER, RUTH ALEXANDRIA, A.B., Ph.D., Instructor in Anatomy, College of Physicians and Surgeons, Columbia University, *630 W. 168th St., New York City.*

MILLER, SHIRLEY P., A.B., A.M., Ph.D., Assistant Professor of Anatomy, *Anatomical Institute, University of Minnesota, Minneapolis, Minn.*

MILLER, WILLIAM SNOW, M.D., Sc.D. (Vice-Pres. '08–'09), Professor of Anatomy (Emeritus), University of Wisconsin, *2001 Jefferson St., Madison, Wis.*

MOODY, ROBERT ORTON, B.S., M.D., Professor of Anatomy, University of California, *2826 Garber St., Berkeley, Calif.*

MOORE, CARL R., A.M., Ph.D., Professor of Zoölogy, *Hull Zoölogical Laboratory, University of Chicago, Chicago, Ill.*

MORGAN, LAWRENCE ONIS, A.B., A.M., Ph.D., Assistant Professor of Anatomy, *University of Cincinnati, College of Medicine, Eden Ave., Cincinnati, Ohio.*

MORRILL, CHARLES V., A.M., Ph.D., Associate Professor of Anatomy, *Cornell University Medical College, 1300 York Ave., New York City.*

MORTON, DUDLEY JOY, M.D., Associate Professor, Department of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*

MOSSMAN, HARLAND W., Ph.D., Assistant Professor of Anatomy, *Science Hall, University of Wisconsin, Madison, Wis.*

MULL, PHILIP L., B.S., M.D., Dean, Professor of Anatomy, *University of Mississippi Medical School, University, Miss.*

MURRAY, WILLIAM S., B.A., M.A., Sc.D., Research Associate, Roscoe B. Jackson Memorial Laboratory, *Box 148, Bar Harbor, Maine.*

MYERS, BURTON D., A.M., M.D., Professor of Anatomy and Dean of the Indiana University School of Medicine, *424 N. Walnut St., Bloomington, Ind.*

MYERS, J. ARTHUR, M.S., Ph.D., M.D., Professor of Preventive Medicine and Chief of Chest Clinic, *University of Minnesota Medical School, Minneapolis, Minn.*

MYERS, MAE LICHTENWALNER, M.D., Professor of Histology and Embryology, Woman's Medical College of Pennsylvania, *Henry Ave. and Abbottsford Rd., East Falls, Philadelphia, Pa.*

NACHTRIEB, HENRY FRANCIS, B.S., Professor Emeritus, Animal Biology, University of Minnesota, *2448 Cedar St., Berkeley, Calif.*

NAÑAGAS, JUAN CANCIO, M.D., Professor of Anatomy, College of Medicine, University of the Philippines, *719 Florida St., Manila, Philippine Islands.*

NEAL, HERBERT VINCENT, A.M., Ph.D., Sc.D., Professor of Zoölogy, Tufts College, *Tufts College, 57, Mass.*

NELSON, WARREN O., A.B., Ph.D., National Research Council Fellow, Department of Zoölogy, *University of Chicago, Chicago, Ill.*

NICHOLAS, JOHN SPANGLER, M.S., Ph.D., Associate Professor of Comparative Anatomy on the Bronson Foundation, *Osborn Zoölogical Laboratory, Yale University, New Haven, Conn.*

NOBACK, GUSTAVE J., B.S., M.A., Ph.D., Professor of Anatomy, New York University, *338 East Twenty-sixth St., New York City.*

NOBLE, GLADWYN K., A.B., M.A., Ph.D., Curator, Department of Herpetology and Experimental Biology, *American Museum of Natural History, 77th Street and Central Park West, New York City.*

NONIDEZ, JOSÉ F., M.S., Sc.D., Assistant Professor of Anatomy, Cornell University Medical College, *1300 York Ave, New York City.*

NORRIS, H. W., A.B., Sc.D., Research Professor of Zoölogy, *Grinnell College, Grinnell, Iowa.*

OBENCHAIN, JEANETTE B., Ph.D., Research Associate, Department of Anatomy, *University of Chicago, Chicago, Ill.*

O'DONOGHUE, CHARLES H., D.Sc., F.Z.S., F.R.S.E., Reader, *Department of Zoölogy, University of Edinburgh, Scotland.*

OKAJIMA, K., M.D., Professor of Anatomy, *Keio University Medical College, Yotsuya, Tokio, Japan.*

O'LEARY, JAMES L., Ph.D., M.D., Assistant Professor of Cytology, *Washington University School of Medicine, St. Louis, Mo.*

OSTERUD, HJALMAR L., A.B., A.M., Ph.D., Professor of Anatomy, *Medical College of Virginia, Richmond, Va.*

OVERHOLSER, MILTON D., A.B., A.M., Ph.D., M.D., Assistant Professor, *Department of Anatomy, University of Missouri, Columbia, Mo.*

PAINTER, THEOPHILUS S., Ph.D., Professor of Zoölogy, Department of Zoölogy, *University of Texas, Austin, Texas.*

PALMER, CARROLL E., M.A., Ph.D., M.D., Instructor, Department of Biostatistics, *School of Hygiene and Public Health, Johns Hopkins University, Baltimore, Md.*

PANKRATZ, DAVID S., A.B., A.M., Ph.D., Assistant Professor of Anatomy, *University of Tennessee, Memphis, Tenn.*

PAPANICOLAOU, GEORGE N., Ph.D., M.D., Assistant Professor of Anatomy, *Cornell University Medical College, 1300 York Ave., New York City.*

PAPEZ, JAMES WENCESLAS, B.A., M.D., Assistant Professor of Anatomy and Neurology, *Cornell University Medical College, Ithaca, N. Y.*

PARKER, GEORGE HOWARD, D.Sc., Professor of Zoölogy and Director of Zoölogical Laboratory, *Harvard University, 16 Berkeley St., Cambridge, Mass.*

PARKER, RAYMOND C., B.A., Ph.D., Associate of the Rockefeller Institute, *66th St. and York Ave., New York City.*

PATTEN, BRADLEY MERRILL, A.M., Ph.D., Associate Professor of Histology and Embryology, School of Medicine, Western Reserve University, *2109 Adelbert Road, Cleveland, Ohio.*

PATTERSON, JOHN THOMAS, B.S., Ph.D., Professor of Zoölogy, University of Texas, *1908 Cliff St., Austin, Texas.*

PERKINS, ORMAN C., A.B., A.M., M.D., F.A.C.P., Professor of Neurology, Long Island College of Medicine, *829 Carroll St., Brooklyn, N. Y.*

PIERSOL, WILLIAM HUNTER, B.A., M.B., Professor of Histology and Embryology, University of Toronto, *35 Dunvegan Road, Toronto, Canada.*

POHLMAN, AUGUSTUS G., M.D. (Ex. Com. '32–), Professor of Anatomy and Dean, Medical School, *University of South Dakota, Vermillion, S. Dak.*

POLJAK, STEPHEN, M.D., Associate Professor of Neurology, Department of Medicine, *University of Chicago, Chicago, Ill.*

POTTER, PETER, M.S., M.D., Oculist and Aurist, *Motor Clinic Bldg., Butte, Montana.*

POYNTER, CHARLES W. M., B.S., M.D. (Ex. Com. '19–'22), Professor of Anatomy, and Dean of the College of Medicine, University of Nebraska, *Forty-second and Dewey Ave., Omaha, Neb.*

PRATT, JEAN PAUL, M.D., Surgeon in Charge of Division of Gynecology and Obstetrics, *Henry Ford Hospital, Detroit, Mich.*

PRYOR, JOSEPH WILLIAM, M.D., Emeritus Professor of Anatomy and Physiology, University of Kentucky, *417 West Second St., Lexington, Ky.*

RADASCH, HENRY E., M.S., M.D., Professor of Histology and Embryology, Jefferson Medical College, *Daniel Baugh Institute of Anatomy, Eleventh and Clinton Sts., Philadelphia, Pa.*

RANSON, STEPHEN W., M.D., Ph.D. (Ex. Com. '21–'24, Vice-Pres. '26–'28), Professor and Director of Neurological Institute, Northwestern University Medical School, *303 East Chicago Ave., Chicago, Ill.*

RASMUSSEN, ANDREW T., Ph.D., Professor of Neurology, *Institute of Anatomy, University of Minnesota, Minneapolis, Minn.*

RAVEN, HENRY C., Associate Curator, Department of Comparative and Human Anatomy, *American Museum of Natural History, 77th St. and Central Park West, New York City.*

RAWLINSON, HERBERT E., M.B., M.D., M.Sc., Lecturer in Histology and Embryology, *McGill University, Montreal, Canada.*

REAGAN, FRANKLIN P., Ph.D., Associate Professor of Anatomy, Medical School, University of Illinois, *1853 West Polk St., Chicago, Ill.*

REED, HUGH D., B.S., Ph.D., Professor of Zoölogy, Cornell University, *McGraw Hall, Ithaca, N. Y.*

DE RÉNYI, GEORGE ST., M.D., Associate Professor of Anatomy, University of Pennsylvania, School of Medicine, *212 S. 39th St., Philadelphia, Pa.*

REVELL, DANIEL GRAISBERRY, A.B., M.B., Professor of Anatomy, *University of Alberta, Edmonton, Alberta, Canada.*

RHINEHART, D. A., A.M., M.D., Professor of Applied Anatomy, University of Arkansas, *4 Armistead Rd., Little Rock, Ark.*

RICE, EDWARD LORANUS, A.B., Ph.D., Sc.D., Professor of Zoölogy, *Ohio Wesleyan University, Delaware, Ohio.*

RIENHOFF, WILLIAM F., JR., A.B., M.D., Assistant Visiting Surgeon, Johns Hopkins Hospital, *1201 North Calvert St., Baltimore, Md.*

RINGOEN, ADOLPH R., A.M., Ph.D., Associate Professor of Zoölogy, *Department of Zoölogy, University of Minnesota, Minneapolis, Minn.*

RIOCH, DAVID MCK., A.B., M.D., Assistant Professor of Anatomy, *Harvard Medical School, Boston, Mass.*

ROBERTSON, ALBERT DUNCAN, B.A., M.A., Professor of Zoölogy, *Western University, London, Ontario, Canada.*

ROBERTSON, W. R. B., A.B., M.S., Ph.D., Associate in Anatomy, *University of Iowa, Iowa City, Ia.*

ROBINSON, BYRON L., M.A., M.D., Professor of Anatomy, *University of Arkansas Medical School, Little Rock, Ark.*

ROGERS, JAMES B., A.M., M.D., Assistant Professor of Anatomy, *University of Louisville, School of Medicine, Louisville, Kentucky.*

ROGERS, WILLIAM MITCHELL, B.S., Ph.D., Assistant Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, 630 West 168th St., New York City.*

ROMER, ALFRED S., B.A., Ph.D., Professor of Vertebrate Palaeontology, *Walker Museum, University of Chicago, Chicago, Ill.*

RUPERT, R. R., M.D., *Suite 416–417 Dalziel Bldg., 532 Fifteenth St., Oakland, Calif.*

RUTH, EDWARD S., M.D., F.A.C.S., Associate Surgeon, Children's Hospital, Los Angeles; *922 Taft Bldg., Hollywood, Calif.*

RUTH, ELBERT B., A.B., Ph.D., Instructor in Anatomy, *University of Rochester, Crittenden Boulevard, Rochester, N. Y.*

SABIN, FLORENCE R., B.S., M.D., Sc.D., LL.D. (Second Vice-Pres. '08–'09, Pres. '24–'26), Member of Rockefeller Institute, *Rockefeller Institute for Medical Research, 66th St. and York Ave., New York City.*

SANTEE, HARRIS E., A.M., Ph.D., M.D., Neurologist, *R. F. D., Box 72, West Chicago, Ill.*

SCAMMON, RICHARD E., Ph.D. (Ex. Com. '23–'26, Vice-Pres. '28–'30), Dean of Medical Sciences and Professor of Anatomy, *University of Minnesota, Minneapolis, Minn.*

SCHAEFFER, JACOB PARSONS, A.M., M.D., Ph.D., Sc.D. (Ex. Com. '24–'29), Professor of Anatomy and Director of the Daniel Baugh Institute of Anatomy, Jefferson Medical College, *4634 Spruce St., Philadelphia, Pa.*

SCHOCHET, SYDNEY S., M.D., Surgeon, *55 East Washington St., Chicago, Ill.*

SCHOEMAKER, DANIEL M., B.S., M.D., Professor of Anatomy and Director of the Department of Anatomy, School of Medicine, St. Louis University, *1402 S. Grand Ave., St. Louis, Mo.*

SCHOUR, ISAAC, B.S., D.D.S., M.S., Ph.D., Associate Professor of Histology, University of Illinois College of Dentistry, *1338 W. Harrison St., Chicago, Ill.*

SCHULTZ, ADOLPH H., Ph.D., Associate Professor of Physical Anthropology, Department of Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

SCHWIND, JOSEPH L., A.B., A.M., Ph.D., Instructor in Anatomy, *Cornell University Medical College, 1300 York Ave., New York City.*

SCOTT, GORDON H., Ph.D., Associate Professor of Cytology, *Washington University School of Medicine, St. Louis, Mo.*

SCOTT, JOHN W., A.B., A.M., Ph.D., Professor of Zoölogy and Director of Pre-Medical Curriculum, *University of Wyoming, Laramie, Wyoming.*

SEIB, GEORGE A., A.B., M.D., Instructor in Anatomy, *Washington University, 2323 Lafayette Ave., St. Louis, Mo.*

SELLING, LAWRENCE, A.B., M.D., Clinical Professor of Medicine, University of Oregon Medical School, *Mayer Building, Portland, Ore.*

SENIOR, H. D., M.D., D.Sc., F.R.C.S. (Vice-Pres. '22–'23, Ex. Com. '33–), Professor of Anatomy, New York University and Bellevue Hospital Medical College, *477 First Ave., New York City.*

SEVERINGHAUS, AURA E., B.S., M.A., Ph.D., Assistant Professor of Anatomy, *College of Physicians and Surgeons, Columbia University, New York City.*

SHANER, RALPH FAUST, Ph.D., Professor of Anatomy, *University of Alberta, Edmonton, Alberta, Canada.*

SHEARER, EDWIN M., Ph.D., Assistant Professor of Anatomy, New York University and Bellevue Hospital Medical College, *477 First Ave., New York City.*

SHEININ, JOHN J., B.S., M.S., Ph.D., M.B., Department of Anatomy, *Northwestern University Medical School, 303 E. Chicago Ave., Chicago, Ill.*

SHELLSHEAR, JOSEPH LEXDEN, M.B., Ch.M., Professor of Anatomy, *University of Hongkong, Hongkong, China.*

SHIELDS, RANDOLPH TUCKER, A.B., M.D., Dean and Professor of Histology and Embryology, School of Medicine, *Shantung Christian University, Tsinan, Shantung, China.*

SHUMWAY, WALDO, A.B., A.M., Ph.D., Professor of Zoölogy, *University of Illinois, Urbana, Ill.*

SIMKINS, CLEVELAND S., A.B., Ph.D., Associate Professor of Anatomy and Embryology, University of Tennessee Medical School, *875 Monroe Ave., Memphis, Tenn.*

SIMPSON, MIRIAM ELIZABETH, A.B., M.S., Ph.D., M.D., Instructor in Anatomy, *University of California, Berkeley, Calif.*

SINGER, EDWARD, M.D., Associate in Anatomy, College of Physicians and Surgeons, Columbia University, *630 W. 168th St., New York City.*

SMITH, BERTRAM GARNER, A.B., Ph.D., Professor of Anatomy, New York University and Bellevue Hospital Medical College, *477 First Ave., New York City.*

SMITH, CHRISTIANNA, A.M., Ph.D., Associate Professor of Zoölogy, *Mount Holyoke College, South Hadley, Mass.*

SMITH, DAVID T., A.B., M.D., Associate Professor of Medicine, Duke University, *Duke Hospital, Durham, N. C.*

SMITH, GEORGE MILTON, A.B., M.D., Attending Surgeon, St. Mary's and Waterbury Hospitals, *Pine Orchard, Conn.*

SMITH, GRAFTON ELLIOT, M.A., M.D., F.R.S., Ch.M., D.Sc., Litt.D., F.R.C.P., Professor of Anatomy, *University College, Gower Street, London, W.C.1, England.*

SMITH, H. P., A.B., M.S., M.D., Professor of Pathology, *University of Iowa School of Medicine, Iowa City, Iowa.*

SMITH, PHILIP EDWARD, M.S., Ph.D., Professor of Anatomy, College of Physicians and Surgeons, Columbia University, *632 West 168th St., New York City.*

SMITH, WILBUR CLEVELAND, M.D., Professor of Gross Anatomy, *Tulane University, New Orleans, La.*

SMITH, WILBUR K., A.B., M.D., Assistant Professor of Anatomy, *University of Rochester School of Medicine and Dentistry, Rochester, N. Y.*

SNYDER, FRANKLIN FAUST, M.D., Assistant, Department of Obstetrics, *Johns Hopkins Hospital, Baltimore, Md.*

SPAULDING, M. H., A.B., A.M., Professor of Zoölogy, University of Montana, *507 South Eighth Ave., Bozeman, Montana.*

SPECTOR, BENJAMIN, M.D., Professor of Anatomy, *Tufts Medical College, 416 Huntington Ave., Boston, Mass.*

SPEIDEL, CARL C., Ph.B., Ph.D., Professor of Anatomy, University of Virginia Medical School, *University, Va.*

STARK, MARY B., Ph.B., M.A., Ph.D., Professor of Histology and Embryology, New York Homeopathic Medical College and Flower Hospital, *450 East Sixty-fourth St., New York City.*

STEVENSON, PAUL HUSTON, B.S., M.A., M.D., Associate Professor of Anatomy, *Peiping Union Medical College, Peiping, China.*

STILES, HENRY WILSON, M.D., Professor of Anatomy, College of Medicine, Syracuse University, *309 S. McBride St., Syracuse, N. Y.*

STOCKARD, CHARLES RUPERT, B.S., M.S., M.D., Ph.D., Sc.D. (Sec.-Treas. '14–21, Ex. Com. '23–'28, Pres. '28–'30), Professor of Anatomy, Cornell University Medical College, *1300 York Ave., New York City.*

STONE, LEON STANSFIELD, Ph.B., Ph.D., Associate Professor of Anatomy, Yale School of Medicine, *Sterling Hall of Medicine, Anatomy Department, Cedar St., New Haven, Conn.*

STONE, ROBERT S., B.A., M.A., M.B., M.D., Associate Professor of Roentgenology, University of California Medical School, University Hospital, *Parnassus and Third Aves., San Francisco, Calif.*

STOPFORD, JOHN SEBASTIAN B., M.D., F.R.S., Professor of Anatomy, The Medical School, *University of Manchester, Manchester, England.*

STRAUS, WILLIAM L., JR., Ph.D., Associate in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

STREETER, GEORGE L., A.M., M.D., Sc.D. (Ex. Com. '18–'20, Pres. '26–'28), Director, Department of Embryology, Carnegie Institution of Washington, *Johns Hopkins Medical School, Baltimore, Md.*

STROMSTEN, FRANK ALBERT, B.S., M.S., D.Sc., Associate Professor of Zoölogy, State University of Iowa, *318 Zoölogy Building, Iowa City, Iowa.*

STRONG, LEON H., Ph.D., Assistant Professor of Anatomy, Medical School, University of Michigan, *1008 E. Medical Building, University of Michigan, Ann Arbor, Mich.*

STRONG, OLIVER S., A.B., A.M., Ph.D., Professor of Neurology and Neuro-histology, Columbia University, *College of Physicians and Surgeons, 630 West 168th St., New York City.*

STRONG, REUBEN MYRON, A.B., A.M., Ph.D. (Ex. Com. '16–'19), Professor of Anatomy, *Loyola University School of Medicine, 706 South Lincoln St., Chicago, Ill.*

STUNKARD, H. W., Ph.D., Professor of Biology, *New York University, New York City.*

SULLIVAN, WALTER EDWARD, A.M., Ph.D., Professor of Anatomy, University of Wisconsin, *Science Hall, Madison, Wis.*

SUNDWALL, JOHN, Ph.D., M.D., Professor of Hygiene and Public Health, Director of the Division of Hygiene and Public Health, University of Michigan, *1832 Vinewood Blvd., Ann Arbor, Mich.*

SWENSON, E. A., A.B., A.M., Ph.D., Associate in Anatomy, *Medical Department, University of Pennsylvania, Philadelphia, Pa.*

SWETT, FRANCIS HUNTINGTON, A.M., Ph.D., Professor of Anatomy, Duke University Medical School, *Box 3710, Durham, N. C.*

SWIFT, CHARLES H., M.D., Ph.D., Associate Professor of Anatomy, *University of Chicago, Chicago, Ill.*

SWINGLE, W. W., A.B., A.M., Ph.D., Professor of Biology, *Princeton University, Princeton, N. J.*

SYKES, GEORGE F., Ph.B., M.A., Assistant Professor of Anatomy, Tufts College Medical School, *416 Huntington Ave., Boston, Mass.*

TERRY, ROBERT JAMES, A.B., M.D. (Ex. Com. '08–'12, '21–'24), Professor of Anatomy, *Washington University School of Medicine, St. Louis, Mo.*

THOMPSON, IAN MACLAREN, B.Sc., M.B., Ch.B., Professor of Anatomy, *University of California, Berkeley, Calif.*

THOMSON, ARTHUR, M.A., M.B., LL.D., F.R.C.S., D.C.L., Professor of Anatomy, *University of Oxford, Department of Human Anatomy, Oxford, England.*

THARALDSEN, CONRAD E., B.S., M.A., Ph.D., Professor of Anatomy, *New York Homeopathic Medical College, York Ave. and 64th St., New York City.*

THORKELSON, JACOB, M.D., *20 West Granite St., Butte, Mont.*

THRO, WILLIAM C., B.S., A.M., M.D., Professor of Clinical Pathology, *Cornell University Medical College, Twenty-eighth St. and First Ave., New York City.*

THURINGER, JOSEPH M., M.D., Professor of Histology and Embryology and Head of Department, University of Oklahoma, School of Medicine, *East 13th and Phillips Streets, Oklahoma City, Okla.*

TILNEY, FREDERICK, A.B., M.D., Ph.D., Professor of Neuro-Anatomy, Columbia University, *Neurological Institute, Medical Center, New York City.*

TODD, T. WINGATE, M.B., Ch.B. (Manc.), F.R.C.S. (Eng.), (Vice-Pres. '20–'21, Ex. Com. '24–'29), Chairman and Director, Brush Foundation, Professor of Anatomy, Director of the Hamann Museum of Comparative Anthropology and Anatomy, Medical Department, *Western Reserve University, 2109 Adelbert Road, Cleveland, Ohio.*

TOWER, SARAH SHELDON, B.S., Ph.D., M.D., Associate in Anatomy, *Johns Hopkins Medical School, Baltimore, Md.*

TRACY, HENRY C., A.B., A.M., Ph.D., Professor of Anatomy, *University of Kansas, Lawrence, Kansas.*

TROTTER, MILDRED, A.B., M.S., Ph.D., Associate Professor of Anatomy, *Washington University School of Medicine, St. Louis, Mo.*

TURNER, CHARLES W., B.S., A.M., Ph.D., Associate Professor of Dairy Husbandry, *University of Missouri, Columbia, Mo.*

TURNER, CLARENCE L., M.A., Ph.D., Professor of Zoölogy, *Northwestern University, Evanston, Ill.*

UHLENHUTH, EDUARD, Ph.D., Professor of Gross Anatomy, *University of Maryland Medical School, Baltimore, Md.*

VAN CAMPENHOUT, ERNEST, M.D., Ph.D., Professor of Histology and Embryology, *University of Montreal, Montreal, Canada.*

VAN CLEAVE, C. D., A.B., Ph.D., Instructor in Anatomy, *University of Pennsylvania Medical School, Philadelphia, Pa.*

VAN DER HORST, C. J., D.Sc., Professor, Head of the Department of Zoölogy, University of Witwatersrand, *P. O. Box 1176, Johannesburg, South Africa.*

VAN WAGENEN, GERTRUDE, A.B., Ph.D., Research Assistant in Obstetrics and Gynecology, Instructor's rank, Yale University, *New Haven Hospital, New Haven, Conn.*

VONDERAHE, A.R., A.B., B.Sc., M.D., Assistant Professor of Anatomy, *University of Cincinnati, College of Medicine, Eden Ave., Cincinnati, Ohio.*

WAITE, FREDERICK CLAYTON, A.M., Ph.D., Professor of Histology and Embryology, Western Reserve University School of Medicine, *2109 Adelbert Road, Cleveland, Ohio.*

WALLIN, IVAN E., M.A., D.Sc., Professor of Anatomy and head of department, Secretary of Faculty, *University of Colorado, School of Medicine, Denver, Colo.*

WALMSLEY, THOMAS, M.D., F.R.S.E., Professor of Anatomy, *Queens University of Belfast, Belfast, Ireland.*

WATERSTON, DAVID, M.A., M.D., F.R.C.S., Ed., Bute Professor of Anatomy, *University of St. Andrews, Bute Medical School, St. Andrews, Fife, Scotland.*

WATKINS, RICHARD WATKIN, S.B., M.D., Instructor in Otolaryngology, Rush Medical College, *5608 Kenwood Ave., Chicago, Ill.*

WATT, JAMES CRAWFORD, M.A., M.D., Professor of Anatomy, University of Toronto, *20 Hawthorne Ave., Toronto, Canada.*

WEATHERFORD, HAROLD LORRAINE, A.B., A.M., Ph.D., Assistant Professor of Histology, *Harvard Medical School, Boston, Mass.*

WEBB, RICHARD L., A.B., M.S., Ph.D., Associate in Anatomy, *College of Medicine, University of Illinois, 1853 W. Polk St., Chicago, Ill.*

WEED, LEWIS HILL, A.B., A.M., M.D., Sc.D. (Ex. Com. '20–'21, Sec.-Treas. '22–'30), Professor of Anatomy and Director, *Johns Hopkins Medical School, Baltimore, Md.*

WHEELER, THEODORA, A.B., M.D., *604 Fifth St., S. W., Rochester, Minn.*

WHITESIDE-HARVEL, BEATRICE, B.A., Ph.D., Voluntary Research Worker, c/o *Guaranty Trust Co., 140 Broadway, New York City.*

WHITNALL, S. E., M.A., M.D., B.Ch., M.R.C.R., L.R.C.P., Robert Reford Professor of Anatomy, *McGill University, Montreal, Canada.*

WIEMAN, H. L., Ph.D., Professor of Zoölogy, *University of Cincinnati, Cincinnati, Ohio.*

WILLARD, WILLIAM A., A.M., Ph.D., Professor of Anatomy, University of Nebraska, *College of Medicine, Forty-second St. and Dewey Ave., Omaha, Neb.*

WILLIAMS, GEORGE D., A.B., A.M., M.D., Ph.D., Assistant Professor of Anatomy, *Washington University School of Medicine, St. Louis, Mo.*

WILLIAMS, ROY GRIFFIN, A.B., A.M., M.D., Assistant Professor of Anatomy, *University of Pennsylvania School of Medicine, Philadelphia, Pa.*

WILLIAMS, STEPHEN CULVER, Ph.D., Associate in Anatomy, *Medical Department, University of Pennsylvania, Philadelphia, Pa.*

WILLIER, BENJAMIN HARRISON, Ph.D., Professor of Zoölogy, *University of Chicago, Chicago, Ill.*

WILSON, JAMES THOMAS, M.A., M.B., LL.D., F.R.S., Professor of Anatomy, *University of Cambridge, Anatomy School, New Museums, Cambridge, England.*

WILSON, LOUIS BLANCHARD, M.D., Director of Mayo Foundation, Professor of Pathology in the University of Minnesota Graduate School, Mayo Clinic, *Walnut Hill Farm, Rochester, Minn.*

WINDLE, WILLIAM F., B.S., M.S., Ph.D., Associate Professor of Anatomy, Northwestern University Medical School, *303 East Chicago Ave., Chicago, Ill.*

WISLOCKI, GEORGE B., A.B., M.D., Parkman Professor of Anatomy, *Harvard Medical School, Boston, Mass.*

WITHERSPOON, THOMAS CASEY, M.D., *15375 Via de las Olas, Pacific Palisades, Calif.*

WITSCHI, EMIL, Ph.D., Professor of Zoölogy, *The State University of Iowa, Iowa City, Iowa.*

WITTENBORG, A. H., M.D., Professor of Anatomy, *College of Medicine, University of Tennessee, Memphis, Tenn.*

WOLFE, JACK M., Ph.D., Instructor in Anatomy, *Vanderbilt University School of Medicine, Nashville, Tenn.*

WOODMAN, ALICE S., M.D., Associate Professor of Histology and Embryology, Boston University School of Medicine, *80 East Concord St., Boston, Mass.*

WOOLLARD, HERBERT H., M.D., Professor of Anatomy, *St. Bartholomew's Hospital Medical School, London, England.*

WORCESTER, JOHN LOCKE, M.D., Professor of Anatomy, University of Washington, *5211 Twenty-first Ave., N. E., Seattle, Wash.*

ZECHEL, GUSTAV, M.D., Associate in Anatomy and Surgery, University of Illinois College of Medicine, *1853 W. Polk St., Chicago, Ill.*

ZIMMERMAN, ARNOLD, Lic. Sc., Ph.D., D.Sc. (Geneva, Switzerland), Assistant Professor of Anatomy, University of Illinois School of Medicine, *1853 W. Polk St., Chicago, Ill.*

ZWEMER, RAYMUND L., A.B., Ph.D., Assistant Professor of Anatomy, College of Physicians and Surgeons, Columbia University, *630 West 168th St., New York City.*